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Precambrian Geology of the West-Central Map Area, Nipigon Embayment, Northwestern Ontario, Lake Nipigon Region Geoscience Initiative

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Open File Report 6164

Precambrian Geology of the West-Central Map Area, Nipigon Embayment, Northwestern Ontario, Lake Nipigon Region Geoscience Initiative

by

C.A. MacDonald, E. Tremblay and R.M. Easton

2005

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Contents

Abstract xv

Introduction 1
- Acknowledgements 1
- Access and Previous Work 4
- Geological Setting 4
- Present Geological Survey 5

General Geology 6
- Overview 6
- Archean 6
  - Metavolcanic Rocks 6
  - Metasedimentary Rocks 10
  - Syntectonic to Posttectonic Mafic to Ultramafic Intrusive Rocks 11
  - Felsic to Intermediate Intrusive Rocks 12
    - Gneissic Suite 12
    - Biotite Granite Suite 14
- Paleoproterozoic 16
  - Diabase Dikes 16
- Mesoproterozoic 16
  - Sibley Group Sedimentary Rocks 16
  - Nipigon Diabase Sill Complex 17
    - Nipigon Diabase Sills 18
    - Inspiration Sill(s) 21
    - Jackfish Island Sill (Jackfish Sill) 22
    - Jackfish-Like Sill(s) 25
    - Geochemistry 25
- Alteration 26
- Structural Geology 30

Geochronology 35

Geophysical and Rock Property Data 35
- Magnetic Susceptibility 36
- Specific Gravity 37
- Ground gravity 40
- Inversion Modelling 42

Recommendations for Exploration 43

References 44

Metric Conversion Table 49

FIGURES

1. Lake Nipigon region, showing the location of the 2003 and 2004 bedrock mapping projects funded by the Lake Nipigon Region Geoscience Initiative 2
2. Simplified geological map of the west-central map area 7
3. Simplified geology of the 2003 northwestern LNRGI bedrock map area 20
4. Sketch illustrating Nipigon sill textures and mineralogy that occur proximal to Sibley Group contacts 24
5. Plot of La/Sm versus Gd/Yb for Proterozoic mafic sills from the northwest and west-central map areas, Nipigon Embayment 28
6. Plot of Zr/Nb versus La/Yb for Proterozoic mafic sills from the northwest and west-central map areas, Nipigon Embayment 28
7. Cross section E–E 31
8. Cross section F–F' 32
9. Cross section G–G' 34
10. Histograms of specific gravity values for mafic volcanic, felsic volcanic, synvolcanic mafic intrusive and gneissic suite rocks 38
11. Histograms of specific gravity values for biotite tonalite suite, Pillar Lake intrusion, biotite granite suite and hornblende suite rocks 38
12. Histograms of specific gravity values for quartz-feldspar prophyry of the English Bay complex, Sibley Group sedimentary and Nipigon sill rocks 39
13. Scatter diagram of magnetic susceptibility versus specific gravity for the Inspiration, Jackfish and Nipigon sills 39
14. Contoured residual Bouguer gravity along the western margin of Lake Nipigon 41

PHOTOS

Photo 1. Photographs of the Archean rock units from the west-central Nipigon Embayment 8

A) Archean mafic pillowed flow, southwest of Kabitotikwia Lake 8

B) Archean mafic pillowed flow 8

C) Contact between pillowed mafic metavolcanic unit and Nipigon diabase sill 8

D) Strongly foliated to locally gneissic rocks of mafic to intermediate metavolcanic origin intruded by a pegmatite dike (lower left) of the biotite granite suite 8

E) Highly deformed, strongly foliated, mafic metavolcanic rocks of the Heaven Lake greenstone belt (lower) are crosscut by a dike of the biotite granite suite 8

F) Archean polymictic cobble conglomerate, southeast of Stucco Lake. 8

Photo 2. Photographs of the Archean rock units from the west-central Nipigon Embayment, part 2 12

A) Graded bedding in polymictic conglomerates south of Amik Lake 12

B) Intrusion breccia south of Kabitotikwia Lake 12

C) Strongly foliated to locally gneissic melagabbro outcrop south of Kabitotikwia Lake 12

D) Protomylonitic potassium feldspar megacrystic biotite granite from south of Kabitotikwia Lake 12

E) Mylontite to gneissic mylonite that forms the southeast-trending contact between syntectonic gabbro and biotite granite south of Kabitotikwia Lake 12

F) Gneissic biotite granite from the east shore of Black Sturgeon Lake 12

Photo 3. Photographs of the Archean and Paleoproterozoic rock units from the west-central Nipigon Embayment 14

A) Mafic gneiss from southeast Black Sturgeon Lake. Hammer for scale 14

B) Biotite granite with amphibolite xenoliths crosscut by pegmatitic dikes in the Little Poshkokagan River area. 14

C) Sibley Group–Archean disconformity from the Little Poshkokagan River valley 14

D) Sibley Group basal conglomerate or "regolith" from the Little Poshkokagan River valley 14

E) Mafic gneiss or layered amphibolite xenolith in biotite granite from the southeast Black Sturgeon Lake area 14

F) Plagioclase porphyritic gabbro dike from the area south of Kabitotikwia Lake. A possible Marathon swarm dike? 14

Photo 4. Photographs of Mesoproterozoic sedimentary and mafic intrusive rocks from the west-central Nipigon Embayment 18

A) Sibley Group siltstone, sandstone and conglomerate beds with atypical subvertical orientation from Tchiatang Bluff area of Lake Nipigon 18

B) Intrusive contact between overlying Sibley Group sandstone and chill margin of Nipigon diabase from the Little Poshkokagan River valley 18

C) Photomicrograph of medium-grained, subophitic to ophitic Nipigon diabase from south of Pishidgi Lake in the 2003 northwestern map area 18

D) Polygonal chill margin of Nipigon diabase from the northeast Black Sturgeon Lake area 18

E) Intrusive contact between older Archean biotite granite and overlying chill margin of Nipigon diabase from the northeast Black Sturgeon Lake area 18

F) Contact between medium-grained Nipigon diabase and medium- to coarse-grained slightly more melanocratic diabase pods 18

Photo 5. Photographs of Nipigon diabase sills from the west-central Nipigon Embayment 22

A) Medium-grained Nipigon diabase sill with medium-grained slightly more leucocratic pods 22

B) Hornfelsed Sibley Group xenoliths (outlined by white lines) in potassium feldspar-rich to monzogabbroic Nipigon diabase sill 22

C) Variolitic fine-grained Nipigon diabase. Pencil tip for scale. Outcrop is located east of Black Sturgeon Lake 22

D) Amygdule in chill margin of Nipigon diabase sill. Coin for scale. Outcrop is located near the northeast shore of Black Sturgeon Lake 22

E) Fine-grained, plagioclase glomeroporphyritic Nipigon diabase proximal to a chill margin contact zone with Sibley Group sedimentary rocks 22

F) Photomicrograph of a medium-grained, subophitic- to ophitic-textured Inspiration sill from west of McLaurin Lake in the 2003 northwest map area 22

Photo 6. Photographs of diabase sills from the west-central Nipigon Embayment 26
A) Prominent horizontal jointing in Inspiration diabase sill. 26
B) Photomicrograph of subophitic olivine melagabbro to peridotite of the Jackfish sill 26
C) Photomicrograph of olivine-rich melagabbro to peridotite of the Jackfish sill 26
D) Photomicrograph showing granular fine-grained olivine in Jackfish sill-like diabase from the Gull River diamond-drill hole 26
E) Potassic alteration or aplitic material within medium-grained diabase located proximal to Sibley Group contact, east of Little Muskrat Lake 26
F) Nipigon diabase joint surface filled with tremolite or wollastonite 26

TABLES

1. Summary of products related to the LNRGI bedrock mapping project 3
2. Lithological units for the west-central map area 5
3. Average whole-rock, major element analyses for each of the 4 possible Mesoproterozoic sill types within the northwest and west-central Nipigon Embayment 29
4. Averaged magnetic susceptibility values of major rock units in the western Nipigon Embayment 36
5. Averaged specific gravity values for major rock units in the western Nipigon embayment 37
6. Comparison of magnetic susceptibility and specific gravity data for sill types in the Nipigon Embayment. 37

MAPS

Map P.3559. Precambrian Geology of the Kabitotikwia Lake area, west-central Nipigon Embayment, Northwestern Ontario ..... back pocket
Map P.3560. Precambrian Geology of the Cheeseman-Black Sturgeon Lake area, west-central Nipigon Embayment, Northwestern Ontario ..... back pocket
Map P.3561. Precambrian Geology of the Max–Muskrat Lake area, west-central Nipigon Embayment, Northwestern Ontario ..... back pocket

CHARTS

A. Geological cross sections and summary diamond-drill logs from the west-central map area ..... back pocket
B. Geophysical models from the LNRGI bedrock map areas ..... back pocket

Miscellaneous Release—Data 146

Geological and Lithogeochemical Data from the Western Nipigon Embayment, 2003 and 2004, Lake Nipigon Region Geoscience Initiative (LNRGI); by C.A. MacDonald and E. Tremblay.This digital data release produced by the Ontario Geological Survey as part of the Lake Nipigon Region Geoscience Initiative (LNRGI) contains new geological and lithogeochemical data from the west-central Nipigon Embayment collected during the 2004 mapping season. Lithogeochemical data from the 2003 northwest map area are also included with this release. These data are being released in conjunction with OFR 6164 and Preliminary Maps P.3559, P.3560, and P.3561. The new geological data consist of sample locations and elevations, field rock names, and magnetic susceptibility measurements. Location data for 1151 stations are given in Universal Transverse Mercator (UTM) projection and grid system, Zone 16, North American Datum 1983 (NAD83). Selected photographs are also included for many of the 2004 outcrop stations. Drill hole logs, magnetic susceptibility and photographs, where available, are also included. The lithogeochemical data are for 671 samples collected during the 2003 and 2004 mapping seasons, and include Nipigon diabase sills, Archean basement rocks, and the English Bay complex. The lithogeochemical data files consist of specific gravity measurements, major oxide, trace element, and assay analyses. These data are organized in spreadsheets in Microsoft® Excel 97 (.xls) and in text files (.txt) on one CD-ROM.

This CD-ROM is available separately from the report.

Abstract

The Lake Nipigon Region Geoscience Initiative (LNRGI) is a two-year, science-focused, Industry-Government-University collaborative study that has been collecting new geoscience data in the Lake Nipigon region of Ontario. Bedrock mapping conducted as part of LNRGI has focused on the western Nipigon Embayment. This report summarizes the results of bedrock mapping conducted in 2004 in the west-central map area of the Nipigon Embayment, and includes geological cross sections for the area. In addition, this report provides a brief overview of the geochemical and geophysical data collected for both the 2003 (northern) and 2004 (west-central) map areas, as well as a synopsis of the results of geophysical modelling in selected parts of the area.

The west-central map area is underlain by Archean metavolcanic rocks that represent the eastward extensions of the Garden Lake, Heaven Lake and Lac des Iles greenstone belts of the Wabigoon Subprovince. In the extreme southern part of the map areas, metasedimentary rocks of the Quetico Subprovince are present. Archean intrusive rocks in the area include syntectonic to posttectonic mafic intrusions, as well as felsic intrusions of the gneissic and biotite granite suites. Paleoproterozoic, north-trending diabase dikes, likely of the Marathon dike swarm, crop out in the southern part of the map area.

The Archean rocks are unconformably to disconformably overlain by sandstones and siltstones of the Mesoproterzoic Sibley Group. All rock units in the area are intruded by diabase intrusions of the Nipigon diabase sill complex. Preliminary geochemical data indicates that there may be 4 chemical subgroups in the 2003 and 2004 map areas, designated as the Nipigon, Inspiration, Jackfish, and Jackfish-like sills.

Three main fault sets are present in the western Nipigon Embayment, and are northeast-, north-, or northwest-trending, respectively. Northeast-trending faults lie parallel to the Archean structural grain, and also form major boundaries between different Archean map units. The north- and northwest-trending faults affect all rock units in the area, and form a series of fault blocks, which control the exposure of various rock units across the map area.

Base-metal and gold mineral potential is present in areas underlain by rocks of the Heaven Lake and Lac des Iles greenstone belts. Gold has also been reported from iron formation intercalated with metasedimentary rocks of the Quetico Subprovince. Platinium group element mineralization in the Nipigon Embayment has so far been located in Mesoproterozoic ultramafic intrusions that are only slightly older than the Nipigon diabase sills. Such intrusions are not present in the 2004 map area. The Jackfish sill, in the 2003 map area, is geochemically similar to the Kitto intrusion. In addition, the Jackfish-like diabase sills have trace element affinities with the Kitto intrusion. Consequently, both the Jackfish sill and the Jackfish-like diabase sills might be targets for nickel-copper-PGE exploration.

Precambrian Geology of the West-Central Map Area, Nipigon Embayment, Northwestern Ontario, Lake Nipigon Region Geoscience Initiative

C.A. MacDonald[1], E. Tremblay[1] and R.M. Easton[1]
Ontario Geological Survey
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[1]Precambrian Geoscience Section, Ontario Geological Survey
Ministry of Northern Development and Mines, Sudbury, Ontario, P3E 6B5

Introduction

The Lake Nipigon Region Geoscience Initiative (LNRGI) is a geoscience-based geological data acquisition and compilation program operated by the Ontario Prospectors Association (OPA) and funded through an agreement with the Northern Ontario Heritage Fund Corporation (NOHFC). The LNRGI also includes partnerships with the private sector, Lakehead University and communities in the Lake Nipigon area. The major aim of the initiative is to attract interest from international and domestic investors to encourage new mineral exploration investment in high mineral potential areas in the region and adjacent areas; provide a framework for informed future land use decisions; and to contribute to a geological synthesis of the region. The initiative includes bedrock mapping projects, airborne magnetic and gamma-ray spectrometry surveys, ground gravity surveys, and targeted surficial geochemical and geochronological studies (Rayner 2004).

A two-year program of bedrock mapping in the western Nipigon Embayment, as part of the LNRGI, was conducted at a scale of 1:50 000 between June 2003 and April 2005, with field work conducted in the summers of 2003 and 2004. Mapping of the southwestern (Hart and MacDonald 2003; Hart and Préfontaine 2004a, 2004b; Hart and Magyarosi 2004a, 2004b) and southern (Hart 2005a, 2005b; Hart and Tolson 2005; Hart, Whaley and Pace 2005) areas of the Nipigon Embayment were completed by the Ontario Geological Survey (OGS) as part of its commitment of in-kind support to the LNRGI (Rayner, Lane and Easton 2003). Mapping of the northern (Hart and MacDonald 2003; MacDonald et al. 2004a, 2004b; MacDonald and Tremblay 2004a; MacDonald 2004) and west-central (MacDonald, Tremblay and Easton 2004; MacDonald, Tremblay and ter Meer 2005a, 2005b; MacDonald et al. 2005; and MacDonald and Tremblay (this study, 2005) map areas was conducted under a contract agreement with the OPA (Rayner, Lane and Easton 2003).

This report summarizes the field observations and results of bedrock mapping conducted in 2004 in the west-central part of the Nipigon Embayment as well as the geochemical findings from both the north (2003-04) and west central (2004-05) map areas (Figure 1). Lithogeochemical data and rock properties data collected during the 2003 and 2004 field seasons are available separately from this report as Miscellaneous Release—Data 146 (MRD 146) (MacDonald and Tremblay 2005). Table 1 summarizes the products and presentations produced as part of this project between 2003 and 2005.

ACKNOWLEDGEMENTS

The authors were assisted by senior assistant Mariska ter Meer, and by junior assistants Roger Fournier, Peter Dalton, Frances Mitchell, Sarah Gates, and James Partridge. Mr. Robert Middleton, East West Resource Corporation, allowed access to diamond-drill core from the Posh, Geikie, Johnspine, Grand Bay properties and provided background information for this map area and the Nipigon Embayment in general. Mr. Darin Wagner of Platinum Group Metals Limited and Mr. Robert Middleton also kindly allowed access to diamond-drill core from the Pebble Lake and Stucco Lake properties.

The staff of the Thunder Bay Resident Geologist office also provided background information on previous geological studies and mineral occurrences.

Enrick Tremblay assisted with creation of the maps, cross sections and database, including the arduous task of compiling data from the numerous and varied sources that appear on preliminary maps P.3559, P.3560, and P3561; as well as compiling and formatting data for MRD 146. Sara Jane McIlraith

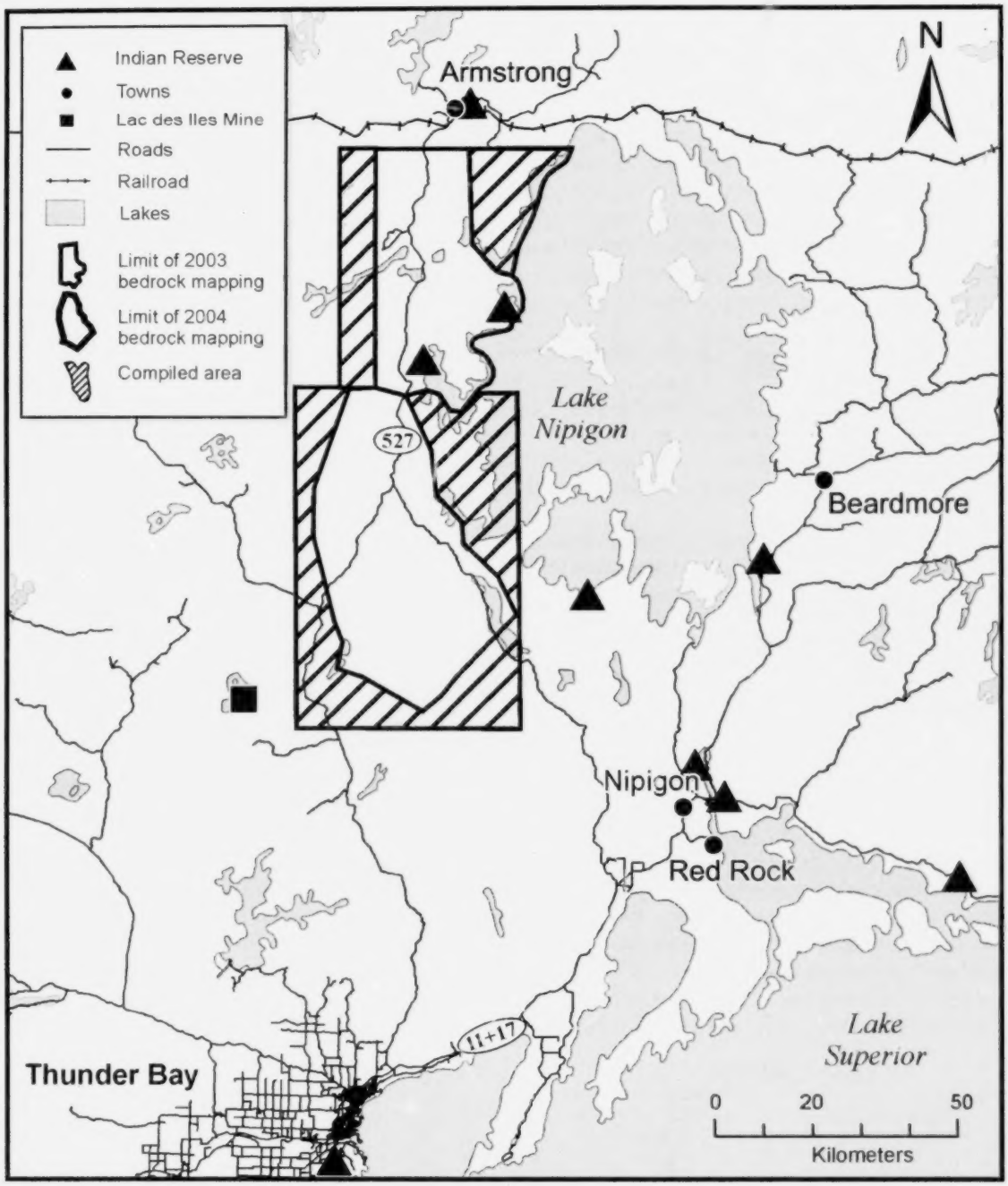


Figure 1. Lake Nipigon region, showing the location of the 2003 and 2004 bedrock mapping projects funded by the Lake Nipigon Region Geoscience Initiative.

edited final drafts of the maps and the geodatabase. The "Geophysical and Rock Property Data" section of this report was written by Desmond Rainsford[1].

Unless otherwise noted, all analytical work for this project was completed by the Geoscience Laboratories, Geoservices Centre, Sudbury.

Table 1. Summary of products related to the LNRGI bedrock mapping project (Project Number 03-304).

Author, Title, Source	Comments
2003 results	
Hart, T.R. and MacDonald, C.A. 2003. Lake Nipigon Region Geoscience Initiative. Proterozoic and Archean geology of the south-central and north areas of the western Nipigon Embayment; *in* Summary of Field Work and Other Activities 2003, Ontario Geological Survey, Open File Report 6120, p.44-1 to 44-15.	Summary of 2003 field work.
MacDonald, C.A. 2004. Precambrian geology of the south Armstrong–Gull Bay area, Nipigon Embayment, northwestern Ontario; Ontario Geological Survey, Open File Report 6136, 42p.	Brief description of geology of 2003 map area, accompanied by Maps P.3536 and P.3537, and chart of cross sections.
MacDonald, C.A., ter Meer, M., Lepage, L., Préfontaine, S. and Tremblay, E. 2004a. Precambrian geology of the Waweig–Wabinosh lakes area, western Nipigon Embayment, northwestern Ontario; Ontario Geological Survey, Preliminary Map P.3536, scale 1:50 000.	Presents results of geological mapping in 2003.
MacDonald, C.A., ter Meer, M., Lepage, L., Préfontaine, S. and Tremblay, E. 2004b. Precambrian geology of the English Bay–Havoc Lake area, western Nipigon Embayment, northwestern Ontario; Ontario Geological Survey, Preliminary Map P.3537, scale 1:50 000.	Presents results of geological mapping in 2003.
MacDonald, C.A. and Tremblay, E. 2004a. Geological and lithogeochemical data from the northwest Nipigon Embayment, Lake Nipigon Region Geoscience Initiative (LNRGI); Ontario Geological Survey, Miscellaneous Release—Data 132.	Preliminary geochemical data from 2003 map area, also drill logs, rock property data and field photographs.
Schandl, E.S. 2004. Petrographic data from the northwest Nipigon Embayment, Lake Nipigon Region Geoscience Initiative (LNRGI); Ontario Geological Survey, Miscellaneous Release—Data 141.	Petrographic description and photomicrographs of samples collected from 2003 map area.
Ontario Exploration and Geoscience Symposium, Toronto, Ontario, December 9-10, 2003	Poster presentation on 2004 mapping results.
Northwest Symposium, Thunder Bay, Ontario, April 6-7, 2004	Oral presentation on 2003 mapping results.
Northwest Symposium, Thunder Bay, Ontario, April 6-7, 2004	Poster presentation on 2003 mapping results.
Institute on Lake Superior Geology, Duluth, Minnesota, May 6-7, 2004. MacDonald, C.A. and Tremblay, E. 2004b. Lake Nipigon Region Geoscience Initiative: Results of bedrock mapping in the northern part of the western Nipigon Embayment, northwestern Ontario, Canada; *in* Institute on Lake Superior Geology, Proceedings, v.50, pt.1, Programs and Abstracts, p.102-103.	Oral presentation on 2003 mapping results.
Institute on Lake Superior Geology, Duluth, Minnesota, May 6-7, 2004. MacDonald, C.A. and Tremblay, E. 2004c. Precambrian geology of the south Armstrong–Gull Bay area, Nipigon Embayment, northwestern Ontario, Canada; *in* Institute on Lake Superior Geology, Proceedings, v.50, pt.1, Programs and Abstracts, p.104-105.	Poster presentation on 2003 mapping results.
2004 results and/or combination of 2003 and 2004 results	
MacDonald, C.A., Tremblay, E., and Easton, R.M. 2004. Lake Nipigon Region Geoscience Initiative: Preliminary results of mapping in the west-central Nipigon Embayment; *in* Summary of Field Work and Other Activities 2004, Ontario Geological Survey, Open File Report 6145, p.49-1 to 49-18.	Summary of 2004 field work.
MacDonald, C.A., Tremblay, E. and Easton, R.M. 2005. Precambrian geology of the west-central map area, Nipigon Embayment, northwestern Ontario, Lake Nipigon Region Geoscience Initiative; Ontario Geological Survey, Open File Report 6164, 48p.	(This report.) Brief description of geology of 2004 map area, with interpretation of geochemical and geophysical data from 2003 and 2004 map areas; accompanied by Maps P.3559, P.3560, and P.3561, chart of cross sections, chart of geophysical models.

[1] Geophysicist, Precambrian Geoscience Section, Ontario Geological Survey, Sudbury.

Author, Title, Source	Comments
Macdonald, C.A., Tremblay, E. and ter Meer, M. 2005a. Precambrian geology of the Kabitotikwia Lake area, west-central Nipigon Embayment, Northwestern Ontario. Ontario Geological Survey, Preliminary Map P.3559.	Presents results of geological mapping in 2004.
Macdonald, C.A., Tremblay, E. and ter Meer, M. 2005b. Precambrian geology of the Cheeseman–Black Sturgeon lakes area, west-central Nipigon Embayment, Northwestern Ontario. Ontario Geological Survey Preliminary Map P.3560.	Presents results of geological mapping in 2004.
Macdonald, C.A., Tremblay, E., ter Meer, M., Hart, T.R. and Easton, R.M. 2005. Precambrian geology of the Max–Muskrat lakes area, west-central Nipigon Embayment, Northwestern Ontario; Ontario Geological Survey, Preliminary Map P.3561.	Presents results of geological mapping in 2004.
MacDonald, C.A. and Tremblay, E. 2005. Geological and lithogeochemical data from the western Nipigon Embayment, 2003-2004, Lake Nipigon Region Geoscience Initiative (LNRGI); Ontario Geological Survey, Miscellaneous Release—Data 146.	Geochemical and rock property data from 2003 and 2004 map areas, drill logs, field photographs.
Schandl, E.S., in press. Petrographic and mineral chemistry data from the western Nipigon Embayment, Lake Nipigon Geoscience Initiative (LNRGI); Ontario Geological Survey, Miscellaneous Release—Data 156.	Petrographic description and photomicrographs of samples collected from 2004 map area.
Ontario Exploration and Geoscience Symposium, Toronto, Ontario, December 14-15, 2004	Oral presentation on 2004 mapping results.
Ontario Exploration and Geoscience Symposium, Toronto, Ontario, December 14-15, 2004	Poster presentation on 2004 mapping results.
Northwest Symposium, Thunder Bay, Ontario, April 5-6, 2005	Oral presentation on 2004 mapping results.
Northwest Symposium, Thunder Bay, Ontario, April 5-6, 2005	Poster presentation on 2004 mapping results.

ACCESS AND PREVIOUS WORK

The west-central map area is located approximately 150 km north of Thunder Bay and west of Lake Nipigon (*see* Figure 1). Access is provided by Highway 527, an excellent network of logging roads and all-terrain vehicle (ATV) trails extending east and west of the highway, as well as many lakes and rivers. Previous work in the map area was conducted by Sage et al. (1974) at a scale of 1:126 720. Sutcliffe (1986) completed geological investigations of the diabase sills. Bedrock mapping of the shore of Lake Nipigon and adjacent areas, at a scale of 1:50 000, was conducted by Sutcliffe (1982a, 1982b). Mapping by Hart (2001) in the Garden Lake greenstone belt and Hart, MacDonald and Lepine (2001a, 2001b) in the Heaven Lake and Lac des Iles greenstone belts adjoins the west-central and southwestern map boundaries of the 2004 map area.

GEOLOGICAL SETTING

Rocks of both the Superior and Southern provinces are represented in the map area (Table 2). The former includes Archean rocks of the volcanic-plutonic central Wabigoon Subprovince that disconformably underlie Mesoproterozoic sedimentary rocks and are intruded by Mesoproterozoic igneous rocks of the Southern Province. Several inliers of Archean rocks occur throughout the map area and consist dominantly of variably foliated felsic to intermediate granitoid intrusions and mafic to felsic metavolcanic rocks. Mesoproterozoic pre-Keweenawan rocks in the map area include sedimentary rocks of the Sibley Group that disconformably overlie and, in the case of English Bay complex, possibly intrude the Archean basement. Nipigon diabase sills intrude and overlie all previously noted rock types in the map area, and are part of the 1110 to 1090 million-year-old Midcontinent Rift-related Mesoproterozoic Keweenawan Supergroup (Blackburn et al. 1991; Sutcliffe 1991; Thurston 1991). More geological background information on the regional geology of the area is available in Sutcliffe (1991), Blackburn et al. (1991) and Thurston (1991)

Table 2. Lithological units for the west-centralmap area.

PHANEROZOIC			
	Cenozoic		
		Quaternary	
			Recent: Stream and swamp deposits.
			Pleistocene: Glacial deposits, sand, gravel, till.
			unconformity
PRECAMBRIAN			
	Proterozoic	Mafic Intrusive Rocks: Nipigon sill complex (1109 $^{+4}/_{-2}$ Ma[1])	
		Subtypes include Nipigon, Inspiration, Jackfish and Jackfish-like sill(s)	
			Fine-, medium-, coarse-, and very coarse-grained diabase; magnetite-rich and/or coarse-grained diabase with intergranular magnetite; gabbro; diabase with very coarse-grained pods, veins, or monzogabbro[2]; inclusion-rich and inclusion-poor diabase chill margins; aplite or very fine-grained felsic phases of diabase.
			intrusive contact
		Sibley Group (>1450)[3]	
		Mudstone, siltstone, sandstone, carbonate breccia, debris flow.	
			unconformity
		Diabase Dikes: Fine- to medium-grained diabase (Marathon swarm[4] *circa* 2130 to 2100 Ma[4])	
			intrusive contact
	Archean	Biotite Granite Suite[5]	
			Unsubdivided; leucocratic to mesocratic; feldspar megacrystic; granodiorite to granite. Includes gneissic, massive, pegmatitic and aplitic varieties.
			intrusive contact
		Hornblende Suite[5]	
			Unsubdivided; tonalite to granodiorite; feldspar megacrystic to granite.
			intrusive contact
		Biotite Tonalite Suite[5]	
			Unsubdivided; granodiorite to granite.
			intrusive contact
		Gneissic Suite[5]	
			Unsubdivided; felsic to intermediate granitoid gneiss.
			intrusive contact
		Syntectonic to Posttectonic Mafic to Ultramafic Intrusive Rocks	
			Gabbro and melanocratic gabbro.
			intrusive contact
		Metasedimentary Rocks	
			Greywacke, siltstone, conglomerate.
		Felsic Metavolcanic Rocks	
			Crystal lapilli tuff, crystal tuff, fine tuff.
		Intermediate Metavolcanic Rocks	
			Lapilli tuff, massive flows.
		Mafic Metavolcanic Rocks	
			Massive and pillowed flows; pillow fragment or hyaloclastite breccias; tuff, lapilli tuff.

Notes: [1] Davis, D.W. and Sutcliffe, R.H. (1985). [2] This unit could represent a late magmatic phase of the sills or assimilation of Sibley Group sedimentary rocks, or a combination of both processes. [3] Heaman et al. (2005). [4] Davis, D.W. and Stott (2003); Hamilton et al. (2002). [5] Contacts between units 11, 12, 15 and 16 may be gradational or obscure, especially in small outcrop.

PRESENT GEOLOGICAL SURVEY

Field work for the west-central map area (Project Number 03-304) took place from June to August 2004. A Garmin® 76S was used to acquire geographic positions for outcrops that were visited during the mapping. An average of no less than 50 readings, but typically 100 or more, was used to reduce error margins on the measurement. Error in x-y space was typically 5 to 7 m, with vertical error estimates around 15 to 20 m. Positions were recorded in Universal Transverse Mercator (UTM) co-ordinates using

the North American Datum 1983 (NAD 83) (UTM Zone 16). Station information is available in MRD 146 (MacDonald and Tremblay 2005). Digital elevation data obtained from the Ontario Ministry of Natural Resources was compared to the recorded Global Positioning System (GPS) positional data as a check for aberrant records. A 1:20 000 scale digital map from Land Information Ontario, Ontario Ministry of Natural Resources, was used as the base for Maps P.3559, P.3560 and P.3561 (*see* back pocket). The existing network of roads was updated on the base map.

General Geology

OVERVIEW

The west-central map area covers 1800 km^2 and extends from just south of Gull River to approximately 4 km south of Little Muskrat Lake. The eastern boundary extends roughly southeast for 55 km through Chief Bay and east of Black Sturgeon Lake, with the southeastern map boundary corresponding to the limit of mapping achieved by Hart and Préfontaine (2004a). The western boundary extends roughly south for 60 km along the west side of Cheeseman Lake toward Poshkokagan Lake. R.M. Easton mapped an additional area (the Max–Mawn lakes area) during the 2004 field season as part of the OGS contribution to the LNRGI. This area was completed to fill in gaps between the 2003–2004 LNRGI mapping projects and previous mapping in the Heaven Lake and Lac des Iles greenstone belts by Hart and MacDonald (2000a, 2000b), as well as mapping in the Max Lake area by Pye (1965). Data from the in-kind mapping, as well as compilation from previous maps in the Max–Mawn lakes area (Pye 1965), Starnes Lake area (Kaye 1969a, 1969b), and Black Sturgeon–Disraeli lakes area (Hart and Préfontaine 2004a; Coates 1968, 1971a, 1971b; Sutcliffe 1982a, 1982b), are included on the southernmost map sheet (Map P.3561, back pocket).

The west-central map area is underlain by Archean granite, greenstone and metasedimentary rocks of the Wabigoon Subprovince, which are unconformably overlain by Proterozoic sedimentary rocks; both Archean and Proterozoic rocks are intruded by Proterozoic diabase sills (Figure 2). Nipigon diabase sills account for 70 to 80% of the rocks within the map area.

ARCHEAN

Metavolcanic Rocks

Archean metavolcanic rocks occur in several parts of the map area:

1. west of Kabitotikwia Lake
2. as a series of at least 3 small inliers extending from just east of Geikie Lake to the northern tip of Black Sturgeon Lake
3. Poshkokagan Lake area (Heaven Lake and Lac des Iles greenstone belts).
4. several areas southwest of the main map area (along strike with the metasedimentary rocks in the Max–Mawn lakes area.

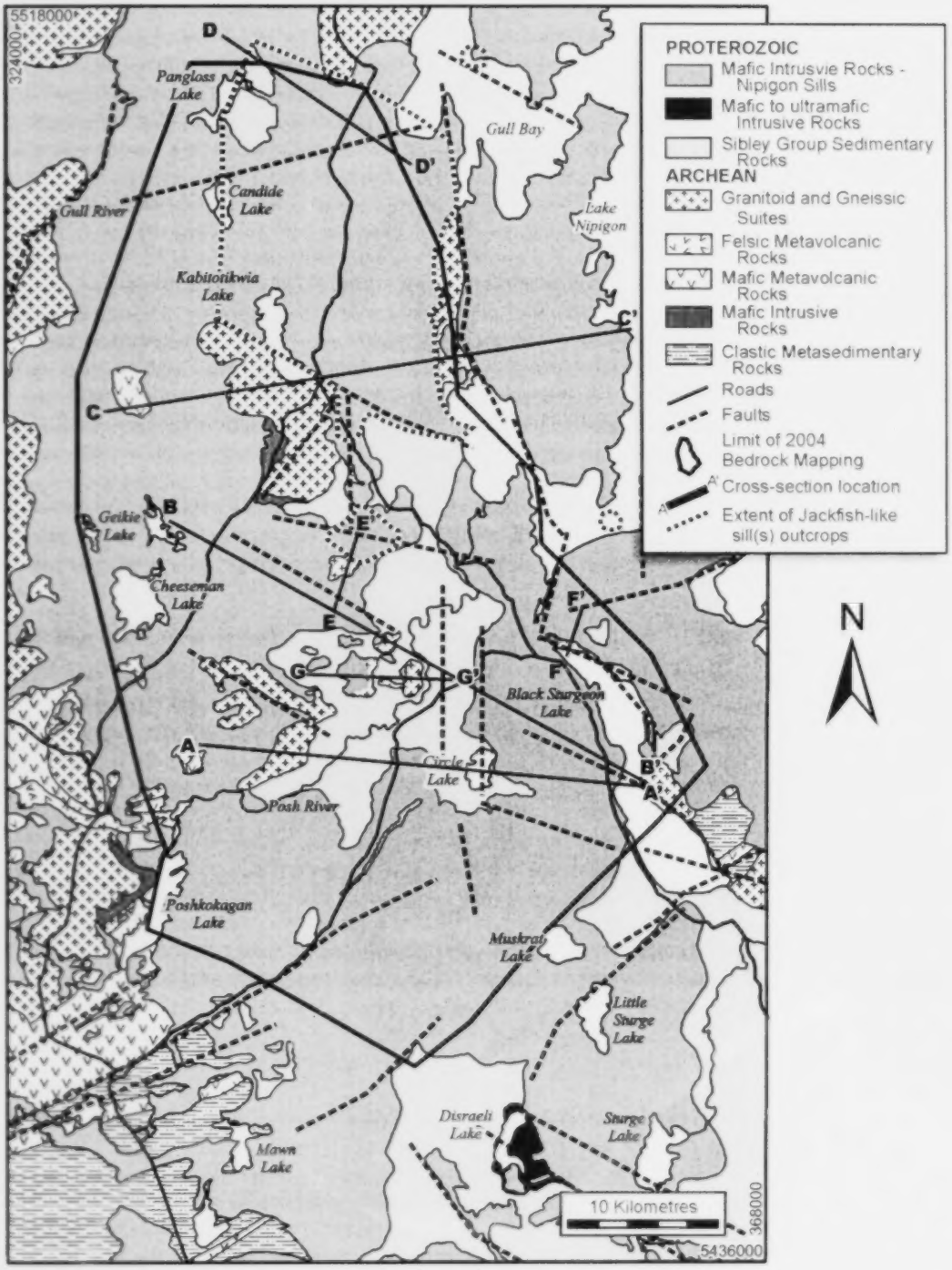


Figure 2. Simplified geological map of the west-central map area.

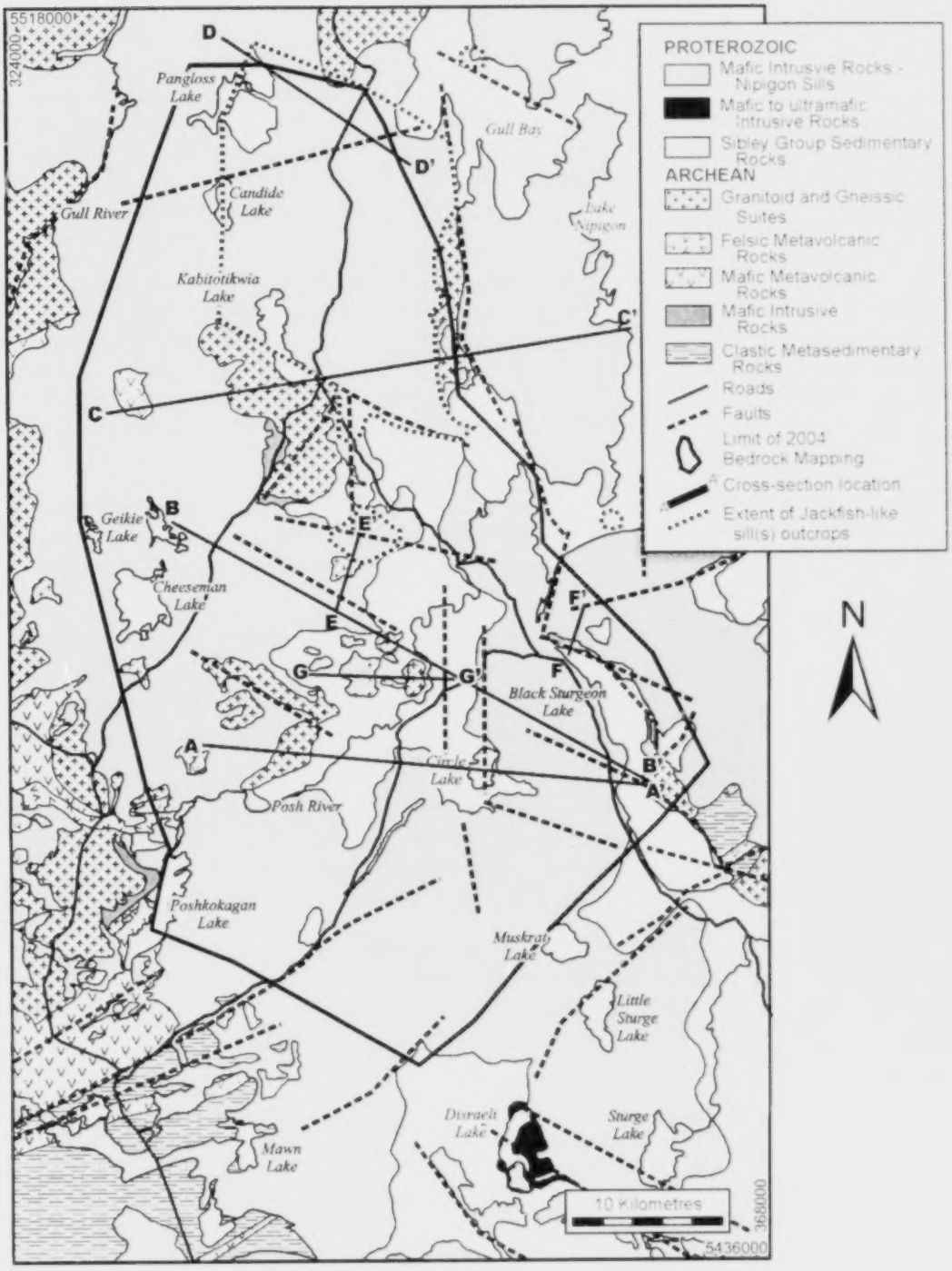


Figure 2. Simplified geological map of the west-central map area

Mafic metavolcanic rocks crop out along relatively new logging roads approximately 10 km west of Kabitotikwia Lake (*see* Figure 2). Rock types consist mainly of variably foliated, pillowed flows with some massive flows, minor vesicular pillow fragment breccia and possible interflow iron formation (Photo 1A). The geographic position of this 6 km^2 Archean inlier, as well as the rock types present, suggests that it is a part of the Garden Lake greenstone belt (Hart 2001).

Three kilometres east of Geikie Lake, an east-west trending sliver of Archean greenstone belt, approximately 1.5 to 2 km long and 50 to 200 m wide, is preserved. Metavolcanic rocks within the sliver consist of pillowed to locally massive mafic metavolcanic rocks. Pillows may range from 10 cm diameter to up to 3 m long on outcrop and are typically well preserved, with visible relict interpillow hyaloclastite and dark green to black positive-weathering selvages that are locally magnetite rich (Photo 1B). Pillows are locally slightly elongated within the plane of a weak to moderate intensity, subvertical east-trending foliation. The Archean greenstone sliver is surrounded and intruded by Nipigon diabase on its northern margin (Photo 1C). The small size of the greenstone sliver could suggest it is a large block or xenolith in the Nipigon diabase; however, the subvertical, east-trending nature of the foliation is consistent with other structures in the Wabigoon Subprovince, and suggests that no rotation of the block occurred during Nipigon diabase emplacement.

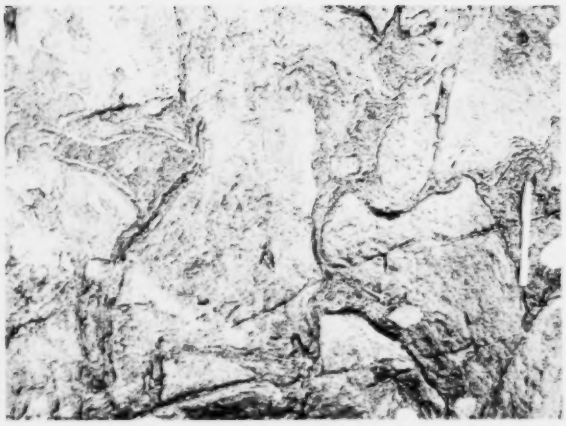
Three other small areas that contain relatively isolated outcrops of highly deformed mafic to intermediate rocks of probable volcanic or sedimentary origin, occur within the map area. The first is located 2 to 3 km south of Kabitotikwia Lake and consists of highly deformed intermediate tuff to gneiss that is intruded by biotite granite to granodiorite. Siltstone to siliceous limestone of the Sibley Group disconformably overlies both granite and intermediate tuff at this location. The second area is located 13 km east southeast of Geikie Lake and consists of strongly foliated to gneissic, mafic to intermediate rocks that are intruded by pegmatite dikes of the biotite granite suite (Photo 1D). The third area consists of strongly foliated mafic metavolcanic rocks and is represented by a single outcrop near the northern tip of Black Sturgeon Lake.

Metavolcanic outcrops in the Poshkokagan Lake area occur near the southern (Lac des Iles greenstone belt) and northern (Heaven Lake greenstone belt) ends of the lake. Outcrops north of Poshkokagan, along the shores of Lever Lake, consist dominantly of moderate to strongly foliated felsic to intermediate tuffs with sparse 3 mm diameter quartz crystal lapilli. Locally, the tuffs also contain vesicle-rich beds 0.5 to 1 m thick. Outcrops of strongly foliated mafic tuff and variably foliated gabbroic amphibolite, interpreted to represent the margin of the Heaven Lake greenstone belt (Hart, MacDonald and Lepine 2001a), also occur north of Lever Lake (Photo 1E). These outcrops form part of the Whistle assemblage (Hart and MacDonald 2000a; 2729 Ma, Tomlinson et al. 2004) of the Heaven Lake greenstone belt.

Photo 1 (facing page). Photographs of the Archean rock units from the west-central Nipigon Embayment.
A) Archean mafic pillowed flow, southwest of Kabitotikwia Lake. Hammer for scale. (UTM 330194E 5494059N, NAD 83, Zone 16). Station 6580.2.
B) Archean mafic pillowed flow. Pen for scale. (UTM 336085E, 5486351N, NAD 83, Zone 16). Station 9501.3.
C) Contact between pillowed mafic metavolcanic unit (MV) and Nipigon diabase sill (NDB). The white line outlines the contact as well as a small diabase dike offshoot into the mafic metavolcanic unit. Person for scale (159.4 cm high). (UTM 336085E, 5486351N, NAD 83, Zone 16). Station 9501.1.
D) Strongly foliated to locally gneissic rocks of mafic to intermediate metavolcanic origin intruded by a pegmatite dike (lower left) of the biotite granite suite. Hammer for scale. (UTM 344875E, 5483243N, NAD 83, Zone 16). Station 8050.5a.
E) Highly deformed, strongly foliated, mafic metavolcanic rocks of the Heaven Lake greenstone belt (lower) are crosscut by a dike of the biotite granite suite. Hammer for scale. (UTM 334066E, 5470218N, NAD 83, Zone 16). Station 7513.1a.
F) Archean polymictic cobble conglomerate, southeast of Stucco Lake. Hammer for scale. (UTM 339748E 5450373N, NAD 83, Zone 16) Station 7157.2.

A)

B)



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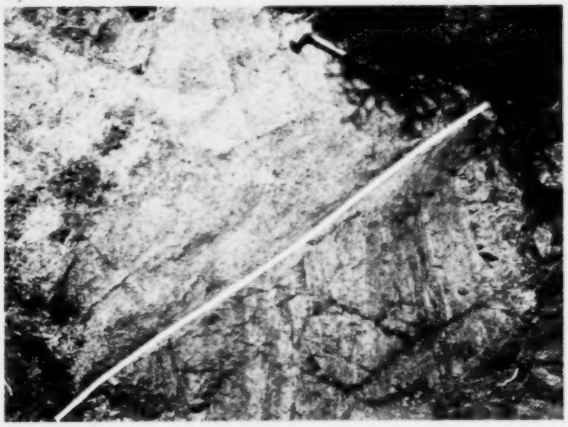

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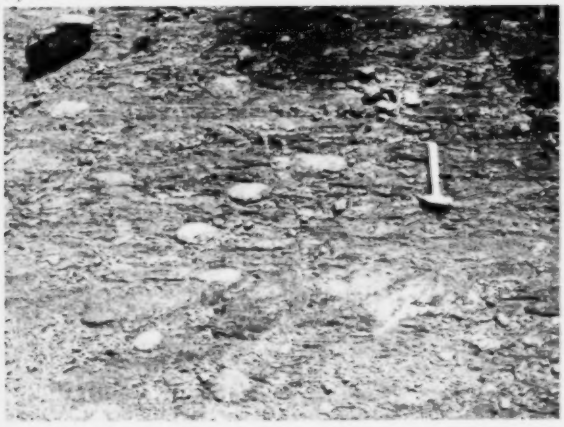


Mafic and felsic metavolcanic rocks crop out along the southwest shores of Poshkokagan Lake. Dominant rock types are massive mafic flows with local mafic tuff to lapilli tuff. Mafic lapilli tuffs typically contain exotic granitoid lapilli as well as siltstone to fine tuff lapilli-sized fragments. Felsic tuff beds of indeterminate but limited thickness also occur interbedded with the mafic metavolcanic rocks and are characterized by their quartz crystal content, which ranges from 10 to 50%. These units represent parts of the northern margin of the Lac des Iles greenstone belt (Hart, MacDonald and Lepine 2001a, 2001b). Two outcrops of massive mafic metavolcanic rock also occur in a small inlier west of Poshkokagan Lake and northeast of Lime Lake. This geographic position would also suggest an association with the Lac des Iles greenstone belt.

Archean metavolcanic rocks in the Max–Mawn lakes area occur as 2 or 3 northeast-trending panels that are present within a dominantly siliciclastic metasedimentary sequence (Pye 1968; Kaye 1969b; this report). The two northern metavolcanic panels each range from 300 to 500 m thick and possibly merge into one another (Max Lake panel) toward the east, north of Geddes Lake (Pye 1968). A southern panel occurs in the vicinity of Peevy Lake and south of Starnes Lake. Dominant rock types in both panels are massive to pillowed mafic volcanic flows, with minor mafic volcanic and intermediate volcanic-derived sandstone and mudstone. Volcanic-derived metasedimentary rocks occur at the north and south contacts of the Max Lake panel, and represent a transition from a volcanic to a sedimentary environment. It is possible that units in the Max Lake panel are repeated due to an anticline. Two isolated outcrops of moderately foliated to sheared amphibolite, located approximately 1.5 km southeast of Little Max Lake, could represent metamorphosed mafic volcanics near the margin of the Peevy Lake volcanic panel.

Metasedimentary Rocks

Archean metasedimentary rocks are present only within the Max–Mawn lakes area. This area forms part of a 10 to 20 km wide continuous belt of metasedimentary and metavolcanic rocks that extends from Max Lake south to DeCourcey Lake (*see* Map P.3561, back pocket). Along Max Creek, a deformation zone, which can be traced at least 10 km east of Highway 527, approximates the southern contact of the Lac des Iles greenstone belt. This metasediment-dominated belt is bounded to the south, near DeCourcey Lake, by Quetico Subprovince felsic intrusive and metasedimentary rocks (T.R. Hart, Ontario Geological Survey, personal communication, 2004). Adjacent to the study area, metamorphic grade in the metasedimentary rocks is low, and ranges from low to middle greenschist facies.

The Archean metasedimentary rocks generally consists of thick-bedded metawacke, metasiltstone and metamudstone, with minor interlayered mafic to intermediate metavolcanic rocks. As noted under "Metavolcanic Rocks", the larger areas of metavolcanic rocks have been grouped into volcanic panels. Locally, particularly near contacts with the volcanic panels (Max Lake volcanic panel), the amount of mudstone within the sedimentary sequence appears to increase.

A package of metaconglomeratic and meta-arenaceous rocks, up to 2 km wide, occurs in a synformal structure lying just south of Max Creek, adjacent to the contact with the Lac des Iles greenstone belt. Dominant rock types are polymictic cobble to boulder metaconglomerate, ranging from sparse to densely packed, as well as medium-grained metawacke and medium-grained, locally cross-bedded, meta-arenite. Densely packed, polymictic cobble and boulder metaconglomerate is most abundant along the greenstone belt contact, and is best exposed on Highway 527 at Max Creek. This unit can be traced east-northeast for roughly 7 km, and mylonitic rocks related to the greenstone belt contact can be traced another 3 km further east, where they occur as rafts in Nipigon diabase sill contacts, or as small outliers between diabase sills. A similar conglomerate also is exposed in outcrops southeast of Stucco Lake (Photo 1F) and south of Amik Lake (Photo 2A). Although the densely packed metaconglomerate superficially

resembles a "Timiskaming-type" metaconglomerate, it can be observed in outcrop grading into both meta-arenite and matrix-rich metaconglomerate. Thus, if the densely packed metaconglomerate is of "Timiskaming" affinity, then so is the entire package of metaconglomerate and meta-arenite present between the deformation zone along Max Creek and the northern margin of the Max Lake volcanic panel. Percival and Sullivan (1988) reported a U/Pb age of 2687±3 Ma from a tonalite cobble from the Max Creek metaconglomerate. This age is a maximum age for deposition.

Overall, the geometry, composition and deposition of the metasedimentary and metavolcanic panels south of Max Creek resemble that observed along the southern margin of the Beardmore–Geraldton greenstone belt located east of Lake Nipigon (e.g., Williams and Stott 1991; Hart, ter Meer and Jolette 2002; Tomlinson et al. 1998), particularly the presence of a northern conglomerate unit containing cross-bedded arenites and the alternation of metasedimentary- and metavolcanic-dominated panels, with the abundance of metasedimentary rocks increasing to the south. If this comparison is valid, than the deformation zone along Max Creek may represent the eastward continuation of either the Paint Lake or Barton Bay deformation zones.

Syntectonic to Posttectonic Mafic to Ultramafic Intrusive Rocks

Mafic to locally ultramafic intrusive rocks crop out in several locations in the west central map area. These intrusions may be subdivided into 2 broad types or associations: 1) syntectonic or greenstone-belt associated gabbros, and 2) posttectonic Archean mafic to ultramafic intrusions. The first type is most common in outcrop and is identified by their similar composition to, and close association with, adjacent or surrounding mafic metavolcanic rocks. The second type is most likely posttectonic, but Archean. It is not limited to a greenstone belt association, and may vary broadly in composition from dominantly melagabbro to locally leucogabbro, gabbro and pyroxenite. This late Archean type may have some similarities with the Lac des Iles and related intrusions.

Near the northern tip of Black Sturgeon Lake at least 3 outcrops of strongly sheared to locally gneissic gabbro to melagabbro occur (*see* Map P.3560, back pocket). These outcrops are proximal to, and locally in association with, highly sheared mafic metavolcanic rocks indicating a greenstone belt association.

A syntectonic gabbroic intrusion also occurs in the vicinity of Dubroy Lake (*see* Map P.3561, back pocket). This intrusion was mapped by Hart, MacDonald and Lepine (2001a) and is interpreted to underlie part of the northwest shore of Poshkokagan Lake. Outcrops of this intrusion were not observed during this study. Other small, concordant syntectonic gabbroic lenses or sills of limited extent commonly occur within the adjacent greenstone belts (*see* Map P.3561, back pocket). These mafic rocks may represent either synvolcanic intrusions related to the metavolcanic rocks they intruded or they may simply be coarser-grained portions of more massive flow units within the volcanic package.

An outcrop of coarse-grained, foliated and moderately to strongly chlorite-altered gabbro occurs north of Lever Lake adjacent to a small mafic metavolcanic inlier. The gabbro locally contains rare bluish quartz, is intruded by dikes of the biotite granite suite, and may be similar to the adjacent Dubroy Lake gabbro.

At least one late mafic to ultramafic intrusion crops out west and south of Kabitotikwia Lake. The body is interpreted as segmented into 2 pieces due to faulting along northeast- and northwest-trending faults (*see* Maps P.3559 and P.3560, back pocket). Outcrops generally consist of moderately to strongly magnetic, and moderately to strongly foliated, gabbro to melagabbro with local areas of more pyroxenitic or dioritic composition. The adjacent biotite granite body is observed to intrude the gabbro in several

locations, with contact zones commonly represented by intrusion breccia (Photo 2B) and dikes of biotite granite. An east-southeast-trending shear zone locally defines the contact between the granite and gabbro in the southernmost segment. Foliation intensity in both the gabbro and granite tends to increase with proximity to the shear zone (Photos 2C and 2D). Where deformation is most intense the gabbro becomes mylonitized and locally interlayered or banded with strongly diminuted potassium feldspar megacrystic granite (Photo 2E).

Other late mafic intrusions, ranging in composition from gabbro to pyroxenite with minor leucogabbro, occur at depth and are associated with several pronounced magnetic anomalies near Geikie Lake, Johnspine Lake and Grand Bay (Ontario Geological Survey 2004a) (*see* Chart B, back pocket). Two samples of gabbro from Johnspine drill hole (JP-01-04) and Geikie drill hole (GK-08) were selected for geochronology in order to confirm their Archean age and whether or not they are contemporaneous with the PGE-hosting Lac des Iles gabbro.

At least two other late gabbro intrusions are recognised outside the map area, including the Kingdon Lake gabbro mapped by Hart, Macdonald and Lepine (2001b) (*see* Map P.3561, back pocket) and the Kitchen Lake–Ruffo Lake gabbro mapped by Hart (2001) in the Garden Lake greenstone belt (not observed in this study). Both intrusions are generally medium- to coarse-grained gabbro with saussuritized plagioclase and local, well-developed, centimetre-scale rhythmic layering. Samples from both the Kingdon Lake and Kitchen Lake intrusions are also being dated as part of the LNRGI in order to determine timing of emplacement relative to the PGE-bearing Lac des Iles gabbro.

Felsic to Intermediate Intrusive Rocks

GNEISSIC SUITE

Gneissic suite rocks are characterized by their strong foliation and heterogeneous layered nature. In the west-central map area, these rocks are typically associated with rocks of the biotite granite suite, particularly in the area east of Black Sturgeon Lake (Photo 2F). Overall composition of gneissic suite rocks in this area is similar to that observed in the biotite granite suite. More mafic layers in the gneiss are generally very thinly layered (<3 cm), with layers commonly ranging from 2 to 30 mm thick. Amphibolite and layered amphibolite xenoliths, similar to those observed in the biotite granite suite, are also common in this unit (*see* Photo 2F). Contacts between rocks of the biotite granite and gneissic suites in the Black Sturgeon Lake area show ambiguous contact relationships, and may be gradational. Toward the eastern contact with the diabase the gneiss becomes increasingly more mafic in composition (Photo 3A). A single outcrop on an island on the west side of Chief Bay contains grey to light grey, layered paragneiss that is cut by coarse-grained to pegmatitic dikes of the biotite granite suite.

Photo 2 (facing page). Photographs of the Archean rock units from the west-central Nipigon Embayment, part 2.
A) Graded bedding in polymictic conglomerates south of Amik Lake. Hammer for scale. (UTM 337369E 5445981N, NAD 83, Zone 16). Station 9082.7.
B) Intrusion breccia south of Kabitotikwia Lake. Dark areas are blocks of melagabbro to pyroxenite in younger biotite granite. Hammer for scale. (UTM 338568E, 5488098N, NAD 83, Zone 16). Station 9512.1a.
C) Strongly foliated to locally gneissic melagabbro outcrop south of Kabitotikwia Lake. Hammer for scale. (UTM 340259E, 5487870N, NAD 83, Zone 16). Station 9514.2.
D) Protomylonitic potassium feldspar megacrystic biotite granite from south of Kabitotikwia Lake. Coin for scale. (UTM 338522E, 5488284N, NAD 83, Zone 16). Station 9511.5.
E) Mylontite to gneissic mylonite that forms the southeast-trending contact between syntectonic gabbro and biotite granite south of Kabitotikwia Lake. GPS unit for scale. (UTM 340061E, 5487854N, NAD 83, Zone 16). Station 8055.1.
F) Gneissic biotite granite from the east shore of Black Sturgeon Lake. Hammer for scale. (UTM 364598E, 5469251N, NAD 83, Zone 16). Station 7605.2a.

A)

B)

C)

D)

E)

F)

Another single outcrop of intermediate to leucocratic gneiss with centimetre-scale layering, and abundant quartz and biotite was observed west of Pangloss Lake (*see* Map P.3559, back pocket).

Rocks of the Archean gneissic to biotite granite suite are also interpreted to underlie a narrow north-trending strip between Chief Bay and Gull Bay. This interpretation is based on geophysical interpretation (Ontario Geological Survey 2004a) and outcrops observed in the Gull Bay – Havoc Lake area during the 2003-04 LNRGI mapping program (MacDonald et al. 2004b).

BIOTITE GRANITE SUITE

Felsic to intermediate intrusive rocks form the bulk of Archean exposures in the west-central map area. Archean inliers of this type occur in several areas:

1. west and south of Kabitotikwia Lake
2. north and south of Cheeseman Lake
3. Wabikon Lake – Little Poshkokagan Creek area
4. the east-central shore of Black Sturgeon Lake

In all areas, rocks of the biotite granite suite are the dominant rock type. Outcrops are generally light to medium pink, and consist of coarse-grained, moderately to strongly foliated, biotite granite to monzogranite. West and south of Kabitotikwia Lake a medium- to coarse-grained, inequigranular to potassium feldspar megacrystic biotite granite crops out over a 50 to 55 km^2 area (*see* Maps P.3559 and P.3560, back pocket). The intrusion is locally crosscut by pegmatite dikes and may contain up to 3% magnetite. A northeast-trending fault may offset or segment the intrusion into two parts.

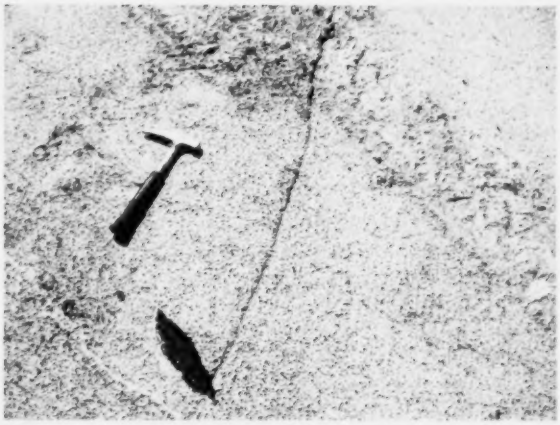
Biotite granite outcrops in the Cheeseman Lake area are similar to those in the Kabitotikwia Lake area: light to medium pink, medium- to coarse-grained, commonly potassium feldspar megacrystic biotite granite.

Granite outcrops in the Little Poshkokagan Creek area are generally light pink, medium- to coarse-grained, weakly foliated to nonfoliated, and may locally tend toward granodioritic compositions. Angular to rounded, 3 to 40 cm long, amphibolite to hornblende diorite xenoliths are common (Photo 3B) as are 10 to 100 cm wide potassium feldspar-rich pegmatite dikes that locally contain magnetite. Light to medium pink, 2 to 100 cm wide, aplite dikes that crosscut both the granite and pegmatitic dikes are also common. Aplite and pegmatite dikes locally have mutual crosscutting relationships.

Photo 3 (facing page). Photographs of the Archean and Paleoproterozoic rock units from the west-central Nipigon Embayment.
A) Mafic gneiss from southeast Black Sturgeon Lake. Hammer for scale. (UTM 336308E, 5468204N, NAD 83, Zone 16). Station 7751.1a.
B) Biotite granite with amphibolite xenoliths crosscut by pegmatitic dikes in the Little Poshkokagan River area. Hammer for scale. (UTM 349434E, 5475080N, NAD 83, Zone 16). Station 7635.1b.
C) Sibley Group–Archean disconformity from the Little Poshkokagan River valley. White lines define areas of underlying biotite granite that poke through the overlying Sibley Group siltstone. Hammer for scale. (UTM 346441E, 5476363N, NAD 83, Zone 16). Station 7663.2.
D) Sibley Group basal conglomerate or "regolith" from the Little Poshkokagan River valley. White lines define biotite granite boulders to cobbles in a siltstone matrix. Hammer for scale. (UTM 342200E, 5476884N NAD 83, Zone 16). Station 7673.5c.
E) Mafic gneiss or layered amphibolite xenolith in biotite granite from the southeast Black Sturgeon Lake area. Hammer for scale. (UTM 364595E, 5469252N, NAD 83, Zone 16). Station 7605.3b.
F) Plagioclase porphyritic gabbro dike from the area south of Kabitotikwia Lake. A possible Marathon swarm dike? Tip of pen magnet for scale. (UTM 338522E, 5488284N, NAD 83, Zone 16). Station 9511.1b.

A)

B)



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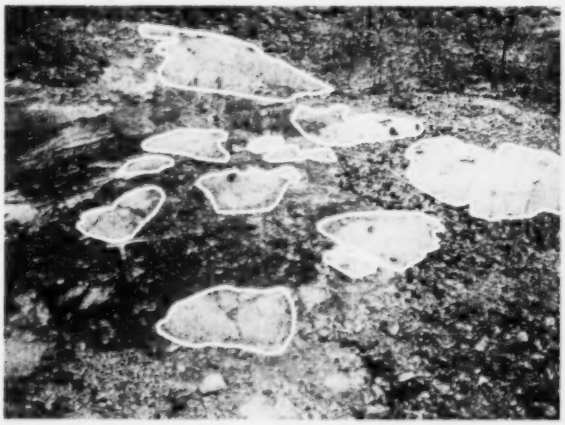

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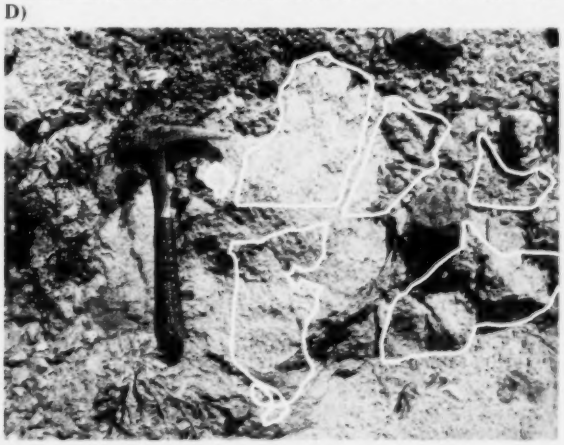

E)

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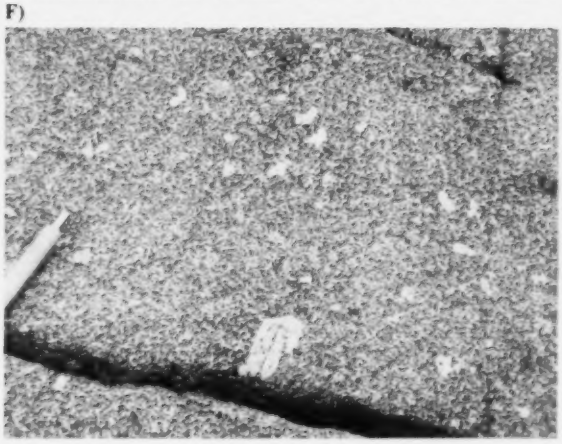

Granite outcrops in the Little Poshkokagan Creek area form a series of topographic highs that may be representative of original Archean paleotopography prior to Proterozoic mafic sill intrusion (*see* Map P.3560, back pocket; and Figure 9). Evidence of a disconformable surface exists in several outcrops where granite-siltstone regolith directly overlies the granite, and marks the base of the Sibley Group in this area (Photos 3C and 3D). Alternatively, the topographic high may be due to vertical offset along one of the many Proterozoic-age faults in the area.

Biotite granite suite outcrops in the area east of Black Sturgeon Lake are generally light to medium pink, medium- to coarse-grained, and vary from weakly to strongly foliated, and are locally gradational into the gneissic suite rocks. Amphibolite and layered amphibolite (mafic gneiss) xenoliths are common (Photo 3E).

PALEOPROTEROZOIC

Diabase Dikes

At least one outcrop of a possible Paleoproterozoic mafic dike was observed south of Kabitotikwia Lake, near the shear zone contact between gabbro and granite intrusions. The dike consists of medium- to coarse-grained plagioclase porphyritic gabbro (Photo 3F). Based on the aeromagnetic surveys of the area (Ontario Geological Survey 2004a) numerous other north-trending dikes of limited width are interpreted to occur within the map area. This is particularly evident on the southernmost map sheet (*see* P.3561, back pocket) where the overlying Nipigon diabase sills do not obscure the magnetic signature of the dikes.

These north-trending dikes are most likely part of the Marathon dike swarm based on their overall north-trending orientation and the plagioclase-porphyritic nature of the outcrop observed south of Kabitotikwia Lake. Ernst et al. (2004), based on paleomagnetic and geochemical studies, observed that most of the north-trending dikes he studied west of Lake Nipigon were part of the Marathon dike swarm. The Marathon dike swarm has 2 distinct age groupings, reversed magnetized dikes at *circa* 2120 to 2130 Ma, and normal magnetized dikes at 2100 to 2110 Ma (Hamilton et al. 2002, Davis and Stott 2003).

MESOPROTEROZOIC

Sibley Group Sedimentary Rocks

Sibley Group sedimentary rocks occur in 4 main areas within the west-central map area:

1. west Pangloss Lake – Candide Lake area
2. Poshkokagan River valley – Lime Creek area
3. Chief Bay – Black Sturgeon Bay
4. Black Sturgeon Lake area
5. other small outcrops and areas

Due to the limited surface exposure of the Sibley Group rocks, and the absence of any stratigraphic sections, no attempt has been made to assign the Sibley Group rocks in the map area to specific formations or members.

Sibley Group sedimentary rocks are interpreted to underlie 2 to 3 small areas covering a total of 16 km^2 in the Pangloss and Candide lakes area (*see* Figure 2). This interpretation is based on the areas' relatively flat topography and geophysical signatures (Ontario Geological Survey 2004a) similar to other areas in the Nipigon Embayment that are underlain by rocks of the Sibley Group. In addition, 2 outcrops of white to yellow-green siltstone to sandstone were observed on the north shores of Candide Lake and another small lake south of Pangloss Lake (*see* Map P.3559, back pocket). An 80 m thickness of similarly described Sibley Group sedimentary rocks also occurs in a drill hole (MT-01), 2 km north of Pangloss Lake (*see* Chart A, Map P.3559, back pocket).

Sibley Group outcrops in the Poshkokagan River valley and Lime Creek area, generally consist of greenish to light greenish grey siliceous to calcareous siltstone that lie unconformably on rocks of the biotite granite suite (*see* Photos 3C and 3D). East-southeast of Circle Lake, several outcrops contain the only stromatolitic limestones observed in the west-central map area. Red to maroon muddy siltstone of limited areal extent also occurs proximal to the stromatolitic unit, either a few metres stratigraphically above or below the limestone. Sibley Group sedimentary rocks are also interpreted to also underlie much of the area west and southwest of Chief Bay as well as south of Lime Creek. This interpretation is due mainly to a combination of flat topography, poor outcrop exposure, and "flat" magnetic signatures that are typical of areas underlain by the Sibley Group in other areas of the Nipigon Embayment (i.e., Hart and Préfontaine 2004a, 2004b).

Along the shores of Lake Nipigon, Sibley Group outcrops locally occur at the base of Nipigon diabase ridges. These outcrops range from light yellow-green limestone on the east side of Chief Bay to more arenaceous siltstone and sandstone, with local clast-supported polymictic pebble to cobble conglomerate, along the shores of Black Sturgeon Bay. Some Sibley Group outcrops along Tchiatang Bluff in Black Sturgeon Bay are atypically oriented, striking west-southwest and dipping 75° to the northwest (Photo 4A). This subvertical orientation of Sibley Group strata may be due to rotation of the beds upon intrusion of the Nipigon diabase sill or alternatively the rotation may be due to vertical movement along the adjacent Black Sturgeon fault. Calcareous outcrops along Chief Bay may have originally been stromatolitic limestone, with the primary stromatolites obliterated during contact metamorphism related to the adjacent Nipigon diabase sills.

Outcrops of the Sibley Group in the Black Sturgeon Lake area generally consist of light beige to buff siliceous, well-sorted sandstone to siltstone. Local areas, limited in extent, of feldspathic sandstone or granule to pebble conglomerates occur toward the south. Locally, limestone may occur interbedded with siltstone to mudstone. Local outcrops of quartzite to marble may occur proximal to Nipigon diabase sill contacts and are a common product of contact metamorphism.

Additional sparse outcrops of light yellow to light yellow-green calcareous mudstone, light yellow to whitish calcareous siltstone, as well as noncalcareous sandstone to siltstone occur locally at the base of Nipigon diabase ridges throughout the map area. Hornfelsed Sibley Group sedimentary rocks are also commonly observed as a thin crust on top of, and as inclusions in, Nipigon diabase chill margins (Photo 4B). Proximal to these contacts, potassium feldspar, chlorite, and hematite alteration types are common in both the Sibley Group sedimentary rocks and in the adjacent Nipigon diabase sills.

Nipigon Diabase Sill Complex

Since the previous report (MacDonald 2004), as a result of the acquisition and analysis of geochemical and geophysical data from the 2003 and 2004 map areas, it has become apparent that the diabase sills in the western Nipigon Embayment may be more heterogeneous than previously thought (e.g., MacDonald and Tremblay 2004b, Hart 2003, Richardson and Hollings 2004). Currently, there is no consensus on

how many geochemical types may be present in the Nipigon Embayment, as some proposed sill types are only represented by a few samples (e.g., Richardson and Hollings 2004). Nonetheless, 4 main sill types are present in the 2003 and 2004 LNRGI bedrock mapping areas. From volumetrically most to least abundant, these are:

1. Nipigon sills (both map areas)
2. Inspiration sills (2003 map area only)
3. Jackfish-like sills (2003 and 2004 map areas)
4. Jackfish sill (2003 map area)

The exact relationship between the Jackfish sill, which intruded the English Bay complex (Figure 3), and the chemically similar Jackfish-like sills has not yet been resolved, as they are geographically separated. For the purposes of this report, they are treated as separate units. Descriptions of all 4 sill types are provided below, as not all of them were fully described in the 2003 bedrock mapping report (MacDonald 2004).

Within the west-central map area, only 2 of the above sill types are present. The dominant type has whole rock and trace element characteristics that are typical of the "Nipigon" sills. The second type has whole rock and mineralogical characteristics similar to typical "Nipigon" type, but with trace element characteristics most similar to the Jackfish sill, located in the 2003 map area (MacDonald and Tremblay 2004a, 2004b; MacDonald et al. 2004; *see* "Geochemistry", this report). Even though the chemically defined "Jackfish-like" type of diabase appears to be geographically restricted to a 250 to 300 km^2 area extending from 11 km south of Kabitotikwia Lake to just east of Pangloss Lake, field characteristics suggest little or no distinguishing features between "Nipigon" and "Jackfish-like" sills. Petrographic study of thin sections from samples of both sill types is ongoing (Schandl, in press), and thus it is premature to state that the 2 sill types are petrographically and texturally similar.

NIPIGON DIABASE SILLS

Nipigon diabase sills intrude and overlie 70 to 80% of the rocks within the map area. Davis and Sutcliffe (1985) reported a combined U/Pb age of 1109 $^{+4}/_{-2}$ Ma from baddeleyite and zircon obtained from 2 sills in the Nipigon Embayment. This age is similar to that of the oldest Osler Group volcanic rocks, which are part of the Keweenawan Supergroup of the Midcontinent Rift. Preliminary U/Pb baddeleyite ages of 1110±3, 1113±2, and 1112±5 Ma from diabase sills at Havoc, Muskrat Lake and Grand Bay, respectively (L.M. Heaman, University of Alberta, written communication, 2004), are within error of the previous age estimate by Davis and Sutcliffe (1985), and suggest relatively rapid emplacement of the Nipigon sills.

Photo 4 (facing page). Photographs of Mesoproterozoic sedimentary and mafic intrusive rocks from the west-central Nipigon Embayment.

A) Sibley Group siltstone, sandstone and conglomerate beds with atypical subvertical orientation from Tchiatang Bluff area of Lake Nipigon. (UTM 359083E, 5483969N, NAD 83, Zone 16). Station 7741.2a.

B) Intrusive contact between overlying Sibley Group sandstone and chill margin of Nipigon diabase from the Little Poshkokagan River valley. Sharpie marker for scale. (UTM 342200E, 5476884N, NAD 83, Zone 16). Station 7673.4.

C) Photomicrograph of medium-grained, subophitic to ophitic Nipigon diabase from south of Pishidgi Lake in the 2003 northwestern map area. (UTM 350762E, 5540939N, NAD 83, Zone 16).

D) Polygonal chill margin of Nipigon diabase from the northeast Black Sturgeon Lake area. Hammer for scale. (UTM 364403E, 5474427N, NAD 83, Zone 16). Station 7561.1a.

E) Intrusive contact between older Archean biotite granite and overlying chill margin of Nipigon diabase from the northeast Black Sturgeon Lake area. Hammer for scale. (UTM 366368E, 5468842N, NAD 83, Zone 16). Station 7749.2a.

F) Contact between medium-grained Nipigon diabase (below the white line) and medium- to coarse-grained slightly more melanocratic diabase pods. Pen for scale. Outcrop is located in the northwest Black Sturgeon Lake area. (UTM 356110E, 5480089N, NAD 83, Zone 16). Station 6725.2.

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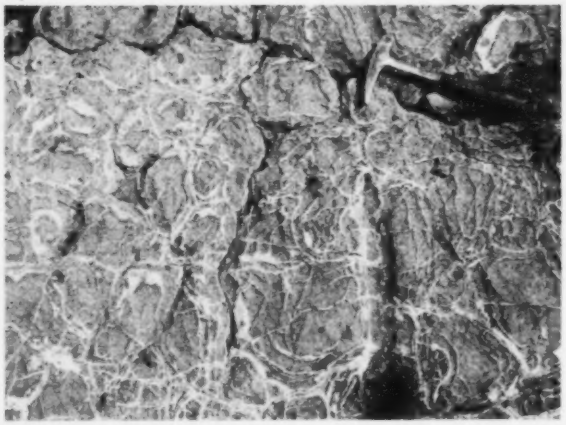

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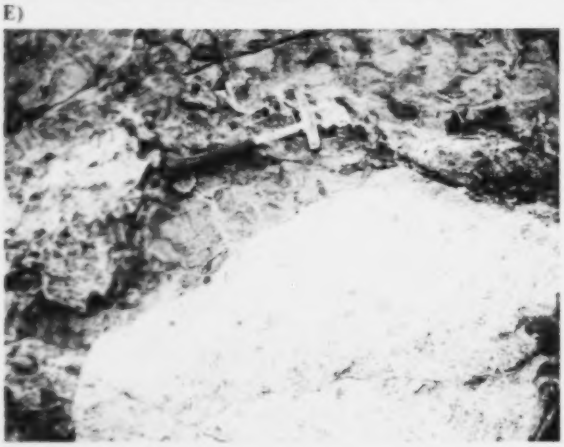

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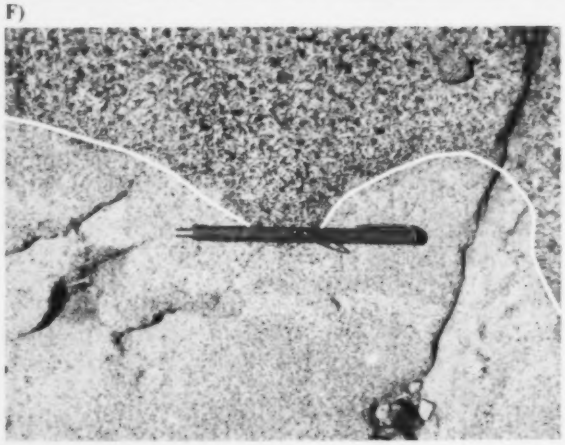

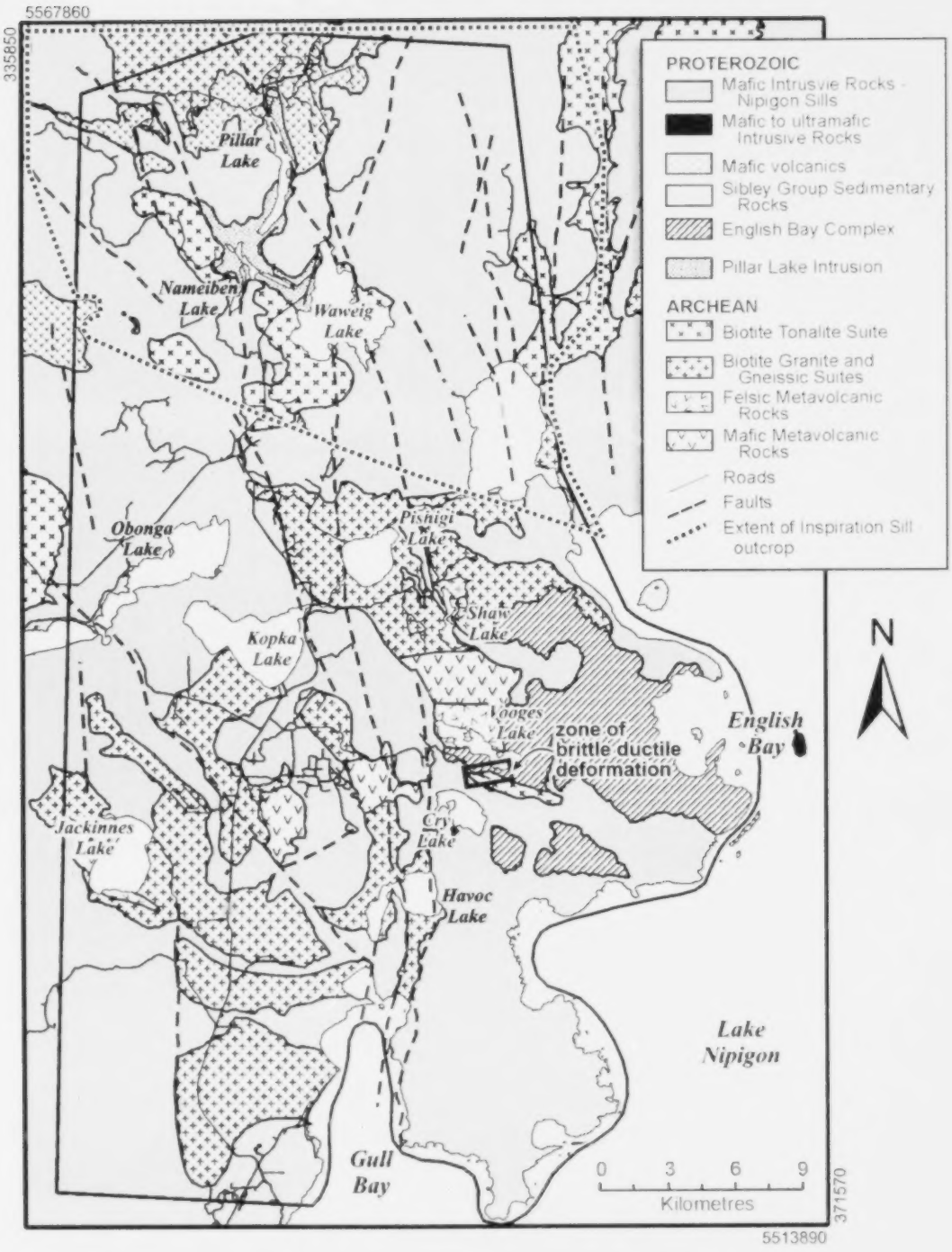

Figure 3. Simplified geology of the 2003 northwestern LNRGI bedrock map area.

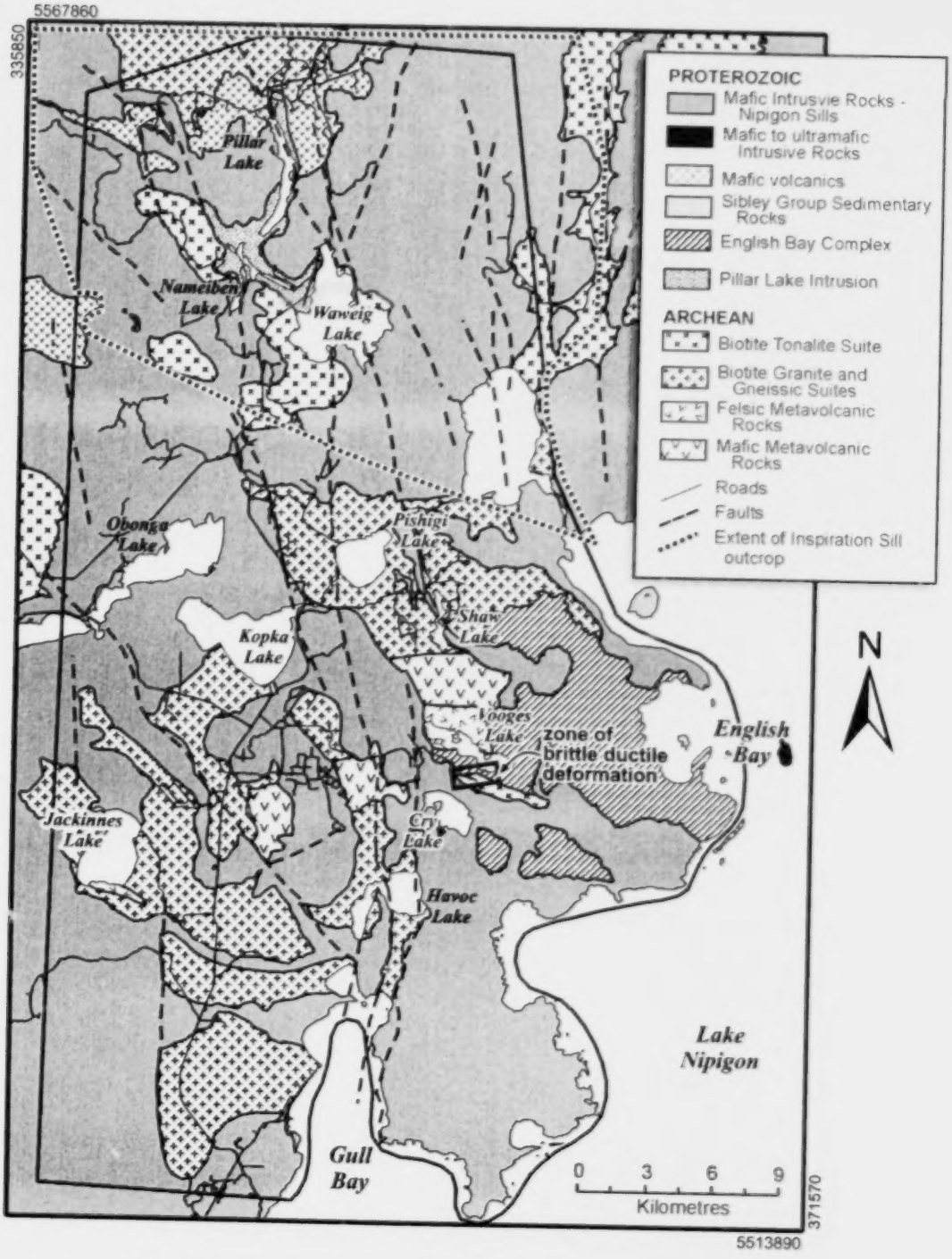

Figure 3. Simplified geology of the 2003 northwestern LNRGI bedrock map area.

The Nipigon diabase sills are generally brown to grey-brown, massive, medium-grained, intergranular-textured and gabbroic in composition. Local variations include fine- and coarse-grained with medium- to coarse-grained varieties commonly displaying ophitic and poikilitic textures (Photo 4C). A magnetite-rich phase also occurs in medium- to coarse-grained sills, and contains greater than 5% intergranular to locally glomeroporphyritic magnetite. A less common trachytoid texture may be present locally within the Nipigon diabase and is marked by a distinctive parallel alignment of plagioclase crystals. Chill margin contacts between the Nipigon diabase and Sibley Group sedimentary rocks are commonly observed, particularly in the Black Sturgeon Lake, Little Poshkokagan Creek and Little Muskrat Lake areas. Generally it is the upper chill margin surface of the diabase sill that is most commonly preserved as the overlying less resistant Sibley Group sedimentary rocks tend to erode away (Photo 4D). Locally, pieces of the overlying Sibley Group may be preserved as a thin skin of hornfelsed material on the surface of or as inclusions within the chill margin. Chill margin contacts are also preserved, although less commonly between the Nipigon diabase sills and the Archean rock units (Photos 1C and 4E). Textural and compositional variation in the Nipigon diabase sills is most marked proximal to contacts with Sibley Group sedimentary rocks. Textural and compositional variations include the presence of medium- to coarse-grained pods and veins, which are slightly more leucocratic or melanocratic than the hosting diabase (Photos 4F and 5A). Monzogabbroic, potassium feldspar-rich or inclusion-rich versions of the diabase may also occur proximal to contacts (Photo 5B). This is thought to possibly represent a late magmatic phase of the sills or assimilation of Sibley Group sedimentary rocks, or a combination of the 2 processes (Hart and Magyarosi 2004a). Other less common textures in diabase–Sibley contact areas include variolitic fine-grained to aphanitic diabase (Photo 5C), vesicular or amygdaloidal fine-grained to aphanitic diabase (Photo 5D) and plagioclase-glomeroporphyritic fine-grained to aphanitic diabase (Photo 5E). These contact zone-related textures and mineralogy are very localized and only typically occur within a 1 to 3 m thickness away from the contact (Figure 4). Within 1 to 2 m of the contact zone into the thickness of the sill, the sill is typically composed of relatively homogeneous medium- to coarse-grained diabase (*see* Figure 4). Sutcliffe (1986) subdivided the sills into an idealized textural and mineralogical stratigraphic section based on observations of sills as thick as 100 m, but this "ideal" section is rarely observed in this map area, nor was it commonly observed in the 2003 map areas (MacDonald 2004; Hart and Magyarosi 2004a).

INSPIRATION SILL(S)

MacDonald and Tremblay (2004b, 2004c) first recognized the Inspiration sill(s) as a distinct map unit, located in the northern part of the Nipigon Embayment (*see* Figure 3), on the basis of trace elements. The sill or sills outcrop over an approximately 400 km^2 area that extends from north of Vale and Inspiration lakes to just south of Bukemiga and Wabinosh lakes (*see* Figure 3). The lower Inspiration sill contact is observed at several locations in the Pillar, Vale and McLauren lakes areas, where it intrudes and overlies flat-lying mafic volcanic and volcaniclastic sedimentary rocks of the Proterozoic Pillar volcanic unit. The Inspiration sill(s) appear, to some extent, to be spatially associated with the Proterozoic Pillar volcanic unit (MacDonald 2004).

The Inspiration sill(s), on outcrop and in hand sample, are very similar to the Nipigon sills. Typically, they are medium grey to medium brown-grey on weathered surface, with overall medium-grained intergranular to subophitic textures (Photo 5F). Local variations proximal to contacts include coarse- to very coarse-grained diabase, potassium feldspar-bearing monzogabbro and potassium feldspar-rich pegmatitic pods; coarse-grained leucocratic diabase pods; coarse-grained ophitic or oikocrystic diabase varieties; and fine-grained to aphanitic diabase. Less than 5% (typically <2%) fine-grained biotite is locally observed in this rock type in hand sample. Only one exposure of an Inspiration sill chill margin was observed, located 2.5 km southwest of Vale Lake and north of the Collins River. The rarity

in occurrence of chill margin contacts for the Inspiration sill may suggest that it is intruded by, and therefore older, than the Nipigon sills. At the aforementioned chill margin contact, the overlying lithology into which the Inspiration sill had intruded was eroded away, thus the contact relationship between it and adjacent outcrops of Nipigon sill is still unclear. However, the close proximity (<900 m) of Nipigon sill outcrops at a slightly higher elevation may alternatively suggest a slightly younger age for the Inspiration sill.

Almost everywhere observed in outcrop, the Inspiration sill(s) displays at least 3 prominent joint sets. The most prominent of the 3 is a closely spaced (≥10 cm to metre-scale) horizontal to subhorizontal joint pattern (Photo 6A). Two other subvertical joint sets oriented at roughly 90° to each other occur at metre to decametre-scale spacing. Weathering of the sill(s) with this joint pattern produces distinctive blocks of square-shaped rubble at the bases of Inspiration sill cliffs and the canyon-like topography in the Inspiration, Spangle and Chimney lakes areas.

Petrographic examination of Inspiration sill thin sections by Schandl (2004) indicated that overall, this sill type was quite altered, with primary clinopyroxene commonly replaced by actinolite. Olivine or pseudomorphs after olivine are extremely rare or absent in this sill type. The presence of biotite in most thin sections is consistent with field observations.

A sample of the Inspiration sill(s) was taken for U/Pb geochronology as part of the LNRGI to compare it with other Geon 11 mafic intrusive and "diabase" ages obtained from elsewhere in the Nipigon Embayment. The sample was collected from a cliff section of diabase 1.5 km west of McLaurin Lake and 2.5 km northeast of the northern tip of Pillar Lake. The Inspiration Sill at this location was observed to intrude and directly overlie the flat-lying Proterozoic Pillar Lake volcanics and volcaniclastic sandstones (*see* Figure 3).

JACKFISH ISLAND SILL (JACKFISH SILL)

The Jackfish Island sill (MacDonald and Tremblay 2004b, 2004c) or just Jackfish sill (MacDonald et al. 2004) is a 50 to 60 m thick olivine gabbro to peridotite sill that intrudes the English Bay complex (*see* Figure 3 for location) (Hart and MacDonald 2003; MacDonald 2004). Sutcliffe and Greenwood (1985b) previously mapped outcrops of this sill on Jackfish and Birch islands as part of the early ultramafic suite due to similarities between it and the Kitto intrusion on the Beardmore side of Lake Nipigon. Examination of the Jackfish sill in outcrop and in drill core (MacDonald and Tremblay 2004a; and Chart A, back pocket) reveals chill margins on both upper and lower sill contacts, thus indicating that sill emplacement postdates the *circa* 1545 Ma English Bay complex. Petrographic examination of thin

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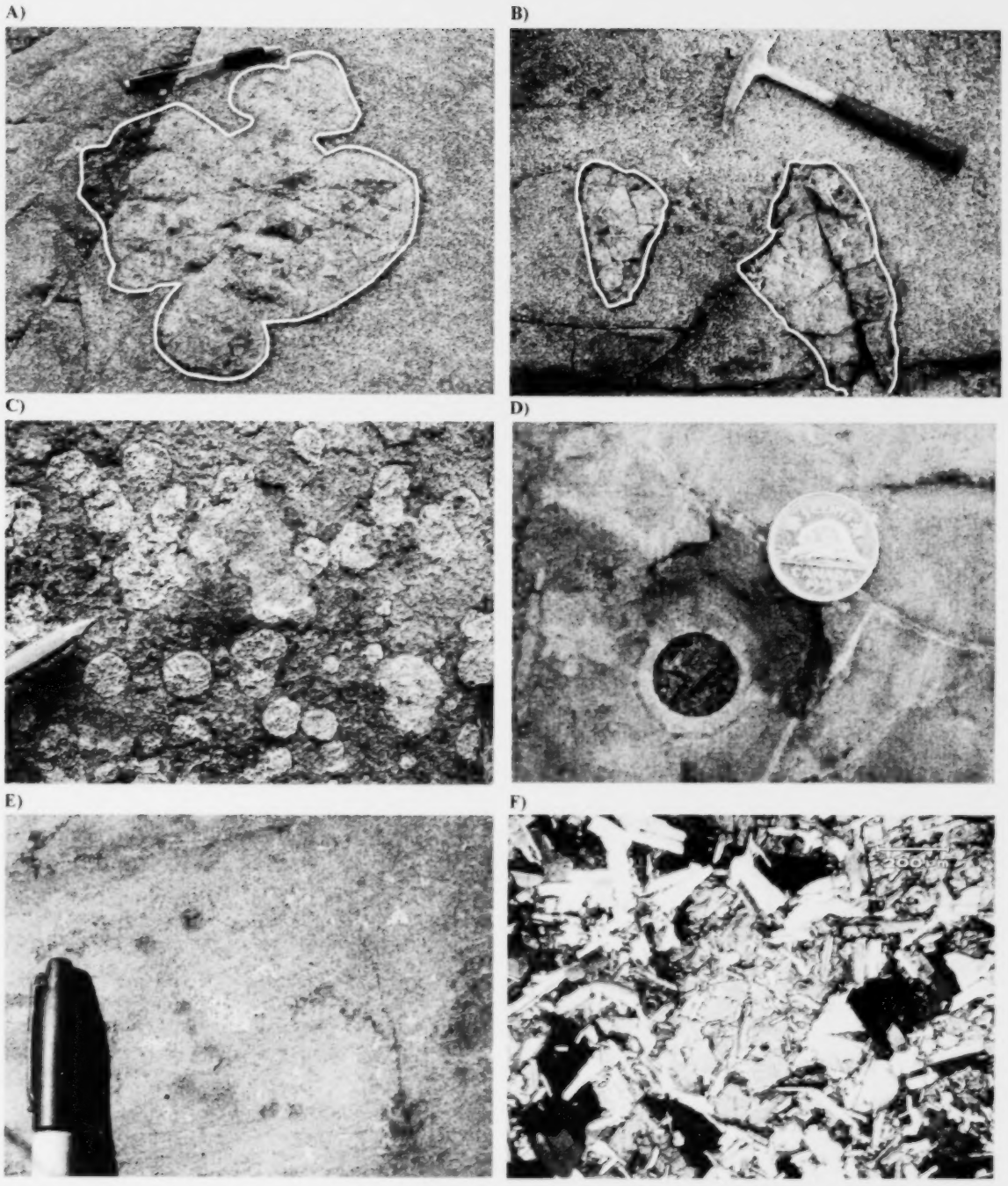
Photo 5 (facing page). Photographs of Nipigon diabase sills from the west-central Nipigon Embayment.
A) Medium-grained Nipigon diabase sill with medium-grained slightly more leucocratic pods. Pencil for scale. Outcrop is located east-northeast of Black Sturgeon Lake. (UTM 366710E, 5473373N, NAD 83, Zone 16). Station 7567.1.
B) Hornfelsed Sibley Group xenoliths (outlined by white lines) in potassium feldspar-rich to monzogabbroic Nipigon diabase sill. Hammer for scale. Outcrop is located east of Black Sturgeon Lake. (UTM 366760E, 5469259N, NAD 83, Zone 16). Station 7748.5.
C) Variolitic fine-grained Nipigon diabase. Pencil tip for scale. Outcrop is located east of Black Sturgeon Lake. (UTM 366760E, 5469259N, NAD 83, Zone 16). Station 7748.1.
D) Amygdule in chill margin of Nipigon diabase sill. Coin for scale. Outcrop is located near the northeast shore of Black Sturgeon Lake. (UTM 364403E, 5474427N, NAD 83, Zone 16). Station 7561.5b.
E) Fine-grained, plagioclase glomeroporphyritic Nipigon diabase proximal to a chill margin contact zone with Sibley Group sedimentary rocks. Tip of sharpie marker for scale. Outcrop is located in the Little Poshkokagan River valley (UTM 344234E, 5476525N, NAD 83, Zone 16). Station 7654.1a.
F) Photomicrograph of a medium-grained, subophitic- to ophitic-textured Inspiration sill from west of McLaurin Lake in the 2003 northwest map area. (UTM 349328E, 5564785N, NAD 83, Zone 16). Station 2231.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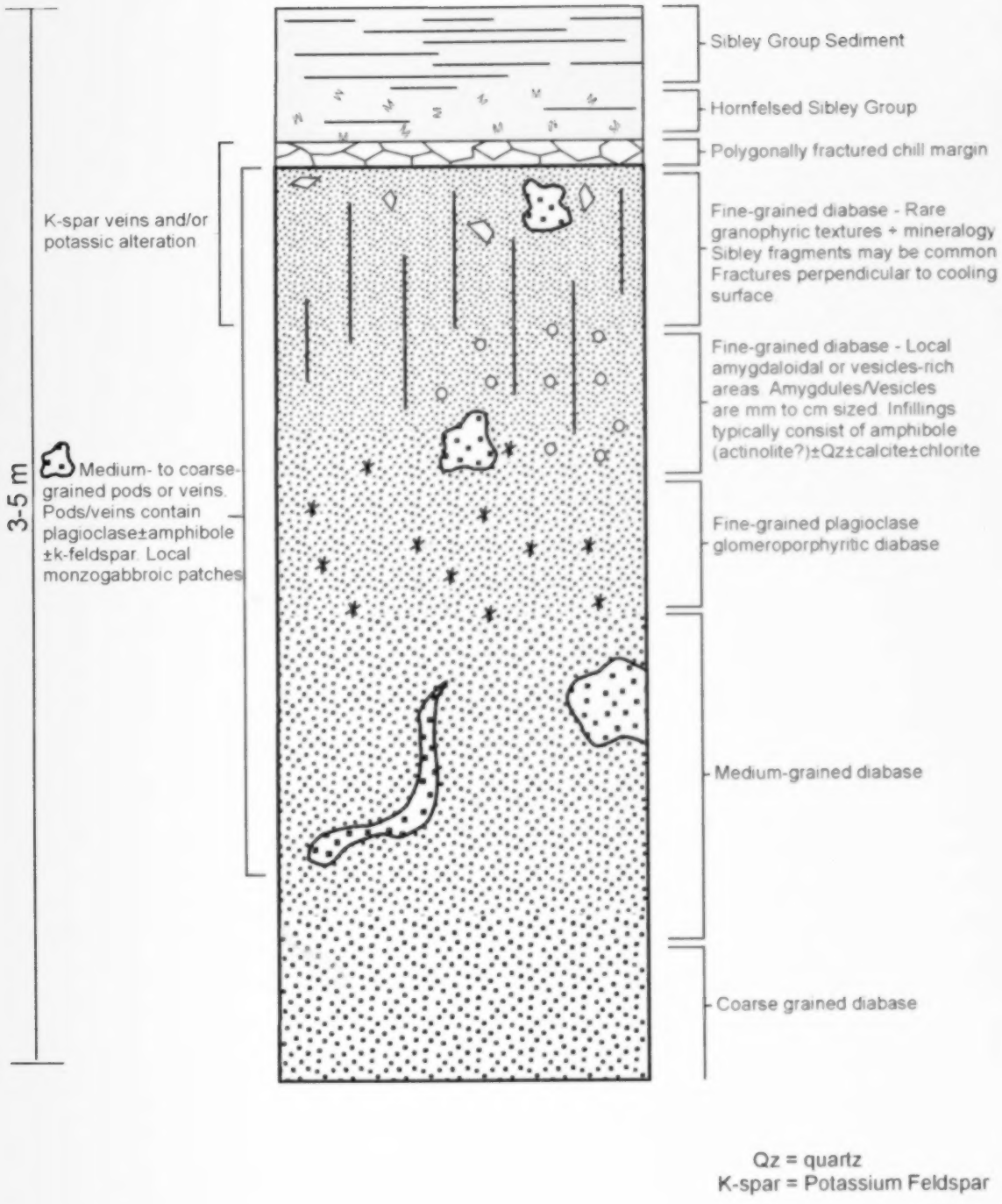

3-5 m
K-spar veins and/or potassic alteration
Medium- to coarse-grained pods or veins. Pods/veins contain plagioclase±amphibole ±k-feldspar. Local monzogabbroic patches
Sibley Group Sediment
Hornfelsed Sibley Group
Polygonally fractured chill margin
Fine-grained diabase - Rare granophyric textures ÷ mineralogy Sibley fragments may be common Fractures perpendicular to cooling surface
Fine-grained diabase - Local amygdaloidal or vesicles-rich areas. Amygdules/Vesicles are mm to cm sized. Infillings typically consist of amphibole (actinolite?)±Qz±calcite±chlorite
Fine-grained plagioclase glomeroporphyritic diabase
Medium-grained diabase
Coarse grained diabase
Qz = quartz
K-spar = Potassium Feldspar

Figure 4. Sketch illustrating Nipigon sill textures and mineralogy that occur proximal to Sibley Group contacts.

sections from the Jackfish sill in drill hole EB-5 by Schandl (2004), indicates that the sill ranges from olivine gabbro to peridotite, with the sill becoming increasingly olivine rich toward its centre. Near the upper and lower contacts of the sill, the rocks consist of medium-grained, intergranular to subophitic-textured olivine gabbro with locally 15% and 25% olivine, respectively. The centre 10 to 20 m of the sill ranges from medium- to coarse-grained, subophitic to ophitic-textured melagabbro to peridotite. Olivine content increases up to 45% in the centre of the sill, approaching peridotitic compositions (Photo 6B) (Schandl 2004). Compositional variations are gradational and are reflected in the variability of MgO contents throughout the thickness of the sill (*see* "Geochemistry").

A sample of olivine melagabbro to peridotite from the southeast shore of Birch Island was collected for U/Pb geochronology as part of the LNRGI (Photo 6C). An age from this sample would confirm or disprove that the Jackfish sill is part of the mafic to ultramafic suite (i.e., similar to the Kitto intrusion).

JACKFISH-LIKE SILL(S)

The chemically defined Jackfish-like sill(s) within the west-central map area occur over a 250 to 300 km^2 area that extends from south of Kabitotikwia Lake to north of the Gull River drill hole (GR-01, see Chart A, back pocket). Whole rock chemistry and mineralogical characteristics (Photo 6D) are similar to the Nipigon sills; however, trace element characteristics are most similar to the Jackfish sill, located in the 2003 map area (MacDonald and Tremblay 2004a, 2004b; MacDonald et al. 2004; *see* "Geochemistry"). One petrographic difference between the Nipigon and Jackfish-like type of sills may be the presence, in the Jackfish-like sills, of fine-grained granular or cumulate olivine (Photo 6D) similar to that observed in the Jackfish sill (Photos 6B and 6C). Although not always the case, olivine present in the Nipigon sills generally tends to be more intergranular to the other rock-forming minerals or a postcumulate phase (Schandl 2004). Additional petrographic study of thin sections from samples of both Nipigon and Jackfish-like sill types is ongoing (Schandl, in press), and thus it is premature to state that the 2 sill types are petrographically and texturally similar.

At least 2 outcrops of the Jackfish-like sill(s) also occur in the 2003 northern LNRGI bedrock map area. The first is on the east side of Gull Bay along the west-southwest shore of the Pike Bay Peninsula. The second sample of Jackfish-like material was collected from just south of Boles Island, in the West Bay area of Lake Nipigon. This second sample was chosen for U/Pb geochronology as part of the LNRGI.

GEOCHEMISTRY

Preliminary analyses of the geochemistry from some of the samples collected during the 2004 field season suggests that there may be 3 to 4 groups of Proterozoic mafic to ultramafic sills in the northern and west-central map areas (Figures 5 and 6). None of the diabase samples analyzed from the 2004 map area plot in the field identified for the Inspiration sills (*see* Figure 5) (MacDonald and Tremblay 2004b); thus, it appears that the extent of the Inspiration sills is restricted to the northeast part of the 2003 northern LNRGI map area. Most diabase samples collected from the west-central map area have trace element characteristics similar to the "typical" Nipigon diabase sills identified in the northern map area (MacDonald 2004; MacDonald and Tremblay 2004b). However, a group of 29 "visually typical" diabase samples from the Voltaire, Penny and Kabitotikwia lakes area have trace element characteristics similar to those of the olivine gabbro to melagabbro Jackfish Island sill (MacDonald 2004; MacDonald and Tremblay 2004b, 2004c). Two other "visually typical" diabase samples collected in 2003 from the Pike Bay Peninsula in Gull Bay also plot in or near the field identified for the Jackfish Island sill (*see* Figures 5

and 6). This Jackfish-like diabase also occurs in the upper parts of diamond-drill holes JP-01-01, JP-4, GR-01 and possibly 98-01 (*see* Chart A, back pocket) and may represent a third type of diabase in the Nipigon Embayment. Alternatively, these samples could be part of the earlier mafic to ultramafic suite of rocks such as the Kitto, Seagull, Hele and Disraeli intrusions. When compared to trace element signatures of other mafic to ultramafic intrusions in the Nipigon Embayment, the Jackfish Island and Jackfish-like samples may be chemically similar to the Kitto intrusion (Hart 2003).

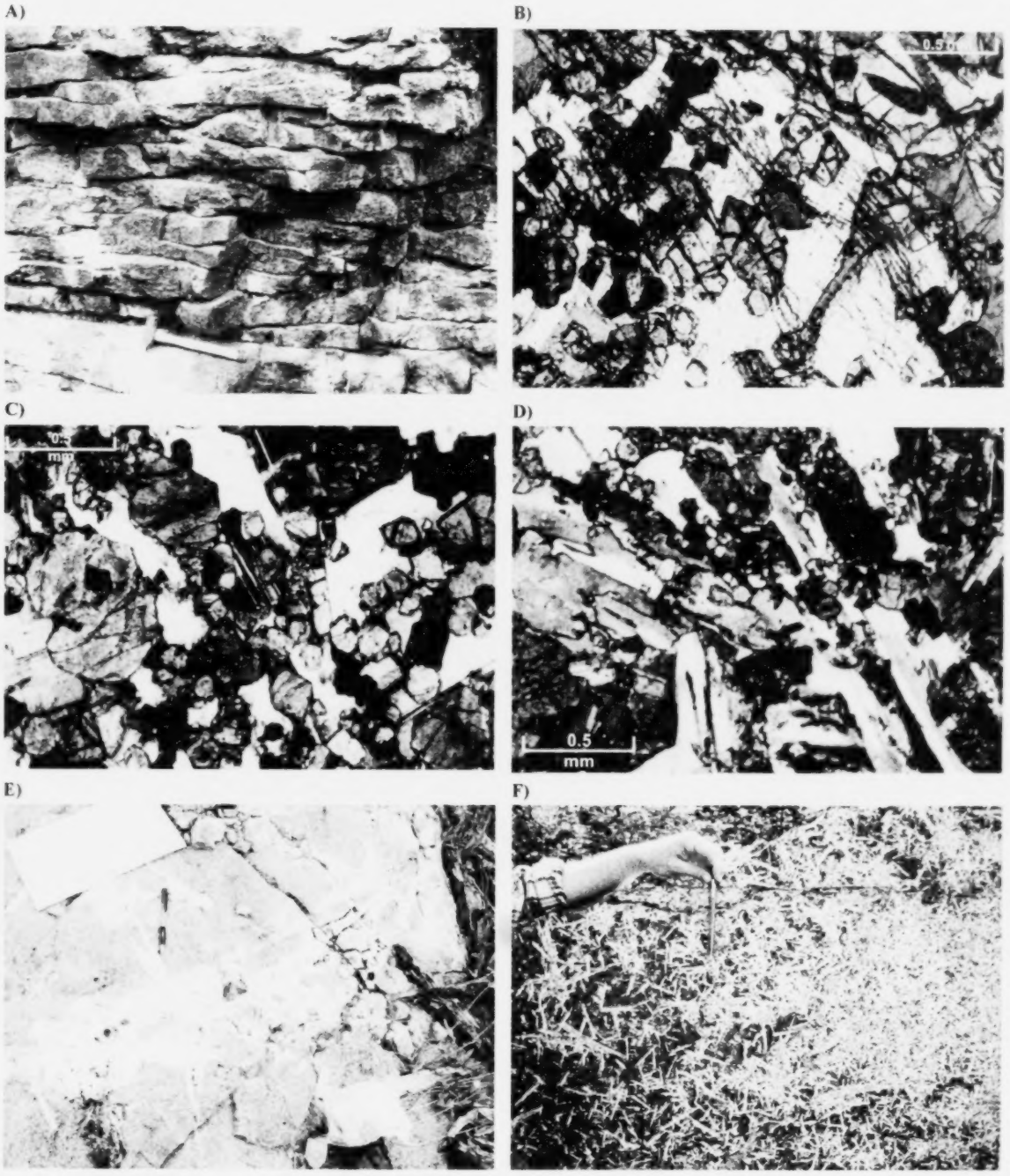
Table 3 presents the average, median, and ranges of major element data as well as for selected trace element ratios for each of the possible mafic sill types in the western Nipigon Embayment. Inspiration, Nipigon and the Jackfish-like diabase samples all have similar major element contents, although TiO_2 is slightly elevated in the Jackfish-like diabase samples (*see* Table 3). Average major elements for the 2003 Jackfish suite samples have elevated MgO, and Fe_2O_3, and lower CaO and Al_2O_3 in comparison to the averages of the Inspiration, Nipigon and Jackfish-like diabase samples (*see* Table 3). Inspiration sills tend to have slightly higher SiO_2 and lower Fe_2O_3 contents and overall generally higher Zr/TiO_2, La/Sm, Nb/Y, and La/Yb ratios; and lower Zr/Nb ratios than the other sill types (*see* Table 3). Jackfish sill and Jackfish-like sill samples tend to have the most similar trace element ratios including Zr/TiO_2, Gd/Yb, Zr/Y, La/Sm, Nb/Y, Zr/Nb, La/Yb and Nb/Th (*see* Table 3).

ALTERATION

Most alteration observed in the west-central map area was related to the development of hornfels in the Sibley Group sedimentary rocks adjacent Nipigon diabase sill contacts. Typical alteration in the sedimentary rocks related to contact metamorphism includes pink potassium feldspar veins, weak to moderate chloritization, and weak to moderate development of actinolite both within the rock and along fracture surfaces.

Nipigon diabase sills typically develop medium- to coarse-grained leucocratic diabase pods, veins, aplite veins, and potassium feldspar-rich pods or monzogranitic varieties of diabase, proximal to Sibley Group contacts (Photo 6E)(*see* Figure 4). The development of potassium feldspar-rich pods and monzogranite has been suggested to result from the assimilation of Sibley Group sedimentary rock (Hart and Magyarosi 2004a).

Photo 6 (facing page). Photographs of diabase sills from the west-central Nipigon Embayment.
A) Prominent horizontal jointing in Inspiration diabase sill. Hammer for scale. Outcrop is located at the south end of Waweig Lake in the 2003 northwest map area. (UTM 351181E, 5552165N, NAD 83, Zone 16). Station 5004.
B) Photomicrograph of subophitic olivine melagabbro to peridotite of the Jackfish sill. Note fine- to medium-grained granular olivine (cumulate). Sample is from diamond-drill hole EB5, interval 205.36 to 205.61 meters. Photomicrograph is from Schandl (2004). (UTM 367504E, 5533119N, NAD 83, Zone 16) Station EB-5.
C) Photomicrograph of olivine-rich melagabbro to peridotite of the Jackfish sill. Note fine-grained granular (cumulate) olivine. Sampled outcrop is located in the 2003 northwest map area on the southeast shore of Birch Island, English Bay area of Lake Nipigon. (UTM 370235E, 5534964N, NAD 83, Zone 16). Station 1127. Photomicrograph is from Schandl (2004).
D) Photomicrograph showing granular fine-grained olivine in Jackfish sill-like diabase from the Gull River diamond-drill hole (GR-01, 52.51-52.71 m). (UTM 342405E, 5513369N, NAD 83, Zone 16). Diamond-drill hole GR-01, interval 52.51-52.71. Photomicrograph is from Schandl (2004).
E) Potassic alteration or aplitic material within medium-grained diabase located proximal to Sibley Group contact, east of Little Muskrat Lake. Pen for scale. (UTM 350747E 5452746N, NAD 83, Zone 16). Station 7102.2.
F) Nipigon diabase joint surface filled with tremolite or wollastonite. Pen magnet for scale. Outcrop is located along Highway 527 east of Cheeseman Lake. (UTM 335022E 5482870N, NAD 83, Zone 16). Station 6518.1.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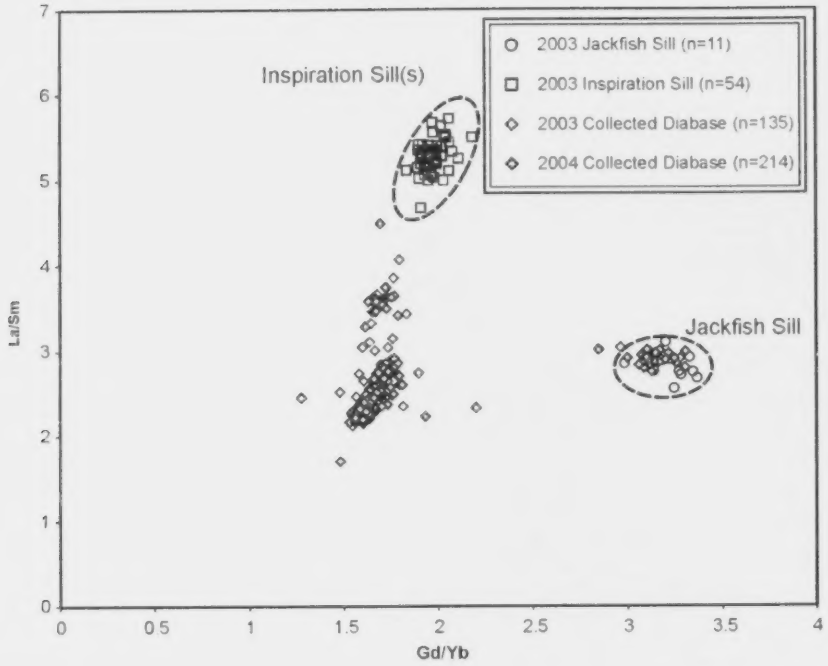


Figure 5. Plot of La/Sm versus Gd/Yb for Proterozoic mafic sills from the northwest and west-central map areas. Nipigon Embayment.

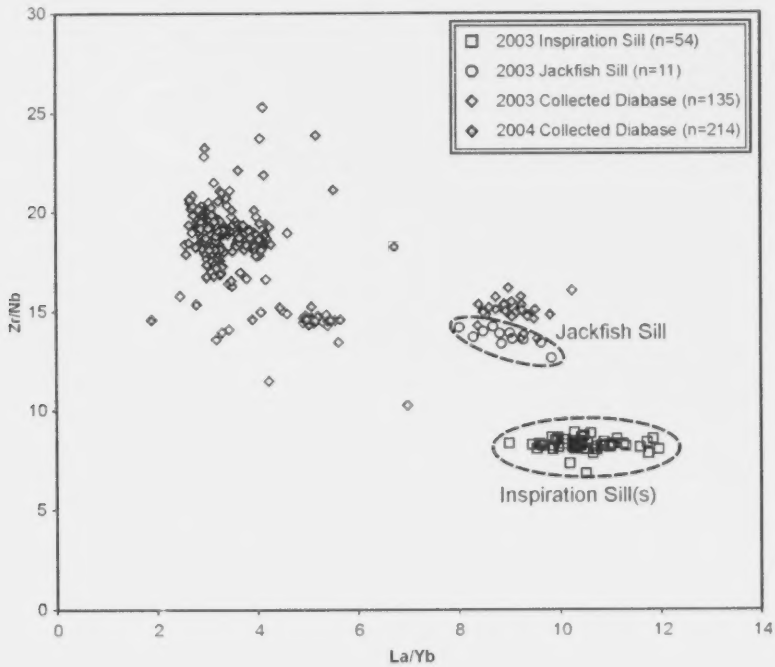


Figure 6. Plot of Zr/Nb versus La/Yb for Proterozoic mafic sills from the northwest and west-central map areas. Nipigon Embayment.

Table 3. Average whole-rock, major element analyses for each of the 4 possible Mesoproterozoic sill types within the northwest and west-central Nipigon Embayment. Data is from (MacDonald and Tremblay 2005). All major elements reported were analysed by X-ray fluorescence (XRF) on fused and pressed powder pellets, at the Geoscience Laboratories, Ontario Geoservices Centre, Sudbury.

Element (wt. %)	**Nipigon sills n=321**			**Inspiration sill(s) n=54**			**Jackfish sill n=11**			**Jackfish-like sills n=29**		
	Average	Median	Range	Average	Median	Range	Average	Median	Range	Average	Median	Range
SiO_2	49.02	49.01	42.07 to 58.46	52.42	52.08	50.52 to 60.89	45.45	45.94	41.43 to 47.3	48.63	48.81	46.3 to 49.92
TiO_2	1.59	1.43	0.71 to 4.18	1.28	1.16	0.86 to 3.33	2.18	2.38	1.39 to 2.87	2.71	2.91	1.25 to 3.35
Al_2O_3	14.50	14.73	10.30 to 18.85	15.01	15.06	12.27 to 16.87	9.41	10.16	6.12 to 12.24	13.77	14.18	10.92 to15.58
Fe_2O_3	15.57	15.02	9.92 to 27.10	11.96	11.63	6.54 to 18.28	16.98	16.62	15.28 to 19.29	15.44	15.55	12.75 to 17.45
MnO	0.22	0.21	0.12 to 0.67	0.18	0.18	0.07 to 0.24	0.23	0.22	0.191 to 0.432	0.18	0.18	0.16 to 0.25
MgO	5.92	6.10	0.97 to 11.72	5.48	5.78	1.64 to 8.19	14.93	13.46	8.04 to 22.94	5.96	5.43	4.31 to 11.4
CaO	9.92	10.15	5.17 to 12.17	9.38	9.77	4.88 to 11.33	7.63	7.95	5.7 to 9.51	9.04	8.83	8.41 to 10.89
Na_2O	2.65	2.59	1.65 to 4.99	3.06	2.92	2.62 to 4.99	2.08	2.23	1.31 to 3.02	3.13	3.20	2.26 to 3.87
K_2O	0.55	0.47	0.23 to 2.10	1.18	1.12	0.61 to 2.16	0.60	0.63	0.35 to 0.87	0.74	0.76	0.4 to 0.96
P_2O_5	0.16	0.14	0.02 to 2.10	0.17	0.15	0.11 to 0.48	0.21	0.23	0.13 to 0.28	0.24	0.24	0.13 to 0.29
LOI	0.38	0.25	0.01 to 3.94	0.62	0.60	0.15 to 1.85	0.57	0.25	0.01 to 2.61	0.71	0.68	0.25 to 1.88
Total	100.39	100.59	98.51 to 101.76	100.74	100.93	99.29 to 101.49	100.21	100.25	99.1 to 100.98	100.56	100.82	98.74 to 101.46
Specific Gravity	3.01	3.02	2.71 to 3.25	2.91	2.92	2.76 to 2.98	3.09	3.07	2.73 to 3.27	3.00	3.01	2.87 to 3.08
Selected ratios	Average	Median	Range	Average	Median	Range	Average	Median	Range	Average	Median	Range
Zr/TiO_2	70.21	66.43	16.75 to 289.06	122.61	118.29	68.99 to 367.16	61.36	62.05	56.52 to 67.16	67.38	65.88	54.93 to 120.96
Gd/Yb	1.68	1.65	1.28 to 3.14	1.98	1.97	1.84 to 2.18	3.23	3.24	2.98 to 3.37	3.08	3.12	1.59 to 3.30
Zr/Y	3.73	3.64	1.67 to 7.25	6.20	6.19	5.60 to 7.43	6.78	6.69	6.06 to 7.56	6.85	7.09	3.43 to 7.53
La/Sm	2.57	2.41	1.71 to 4.50	5.30	5.30	4.68 to 5.72	2.81	2.76	2.56 to 3.10	2.90	2.91	2.35 to 3.04
Nb/Y	0.21	0.20	0.11 to 0.48	0.75	0.75	0.68 to 0.99	0.50	0.48	0.44 to 0.56	0.46	0.47	0.18 to 0.52
Zr/Nb	18.36	18.74	9.98 to 25.30	8.25	8.27	6.83 to 8.90	13.68	13.71	12.64 to 14.24	15.16	15.04	13.62 to 19.25
Hf/Sm	0.72	0.72	0.40 to 0.94	0.79	0.78	0.71 to 0.91	0.70	0.70	0.67 to 0.73	0.70	0.71	0.39 to 0.73
La/Yb	3.55	3.19	1.90 to 9.25	10.47	10.38	9.00 to 11.95	8.91	8.85	8.02 to 9.83	8.90	9.06	2.94 to 10.25
Nb/Th	3.73	3.92	1.16 to 8.04	4.11	4.09	3.75 to 5.05	6.28	6.34	5.65 to 6.75	5.37	5.38	3.85 to 6.33

Deposition of alteration minerals along joint surfaces in Nipigon diabase sill is common and may be due to late magmatic hydrothermal fluids circulating through these joints in the final stages of cooling or due to percolation of later groundwater fluids. These joints may commonly contain chlorite, actinolite, magnetite, and possibly tremolite or wollastonite (Photo 6F).

Hematite alteration is also common within Nipigon diabase sills where diabase with a higher magnetite content has been weathered.

Specular and earthy varieties of hematite were observed to occur in a red to maroon mudstone of the Sibley Group in the Circle Lake area. Specular hematite in these outcrops is typically fracture controlled.

STRUCTURAL GEOLOGY

There are at least 3 prominent fault sets within the map area:

1. a northeast-trending set
2. a north-trending set
3. a northwest-trending set

The northeast-trending set, such as in the Max–Mawn lakes area, appears to correlate with structures in the central Wabigoon Subprovince such as the southern margin of the Lac des Iles greenstone belt (Max Creek fault) and the Max Lake fault (*see* Figure 2). The geophysical signature of many of these structures disappears or becomes obscured to the east by the strong magnetic signature of the overlying Nipigon diabase sills (Ontario Geological Survey 2004a). Fabric development in the Archean rocks tends to mirror these northeast-trending structures and typically consists of weak to moderate intensity, east- to northeast-trending mineral foliations that also correlate well with regional trends in the central Wabigoon Subprovince. The exception to this is the occurrence of at least one northwest-trending shear zone that is oriented at odds to other Archean structures in the area. This shear zone is at least 50 to 350 m wide and is observed in 3 locations in the map area. The first location is south of Kabitotikwia Lake near the contact between rocks of the biotite granite suite and the syntectonic mafic intrusive suite. Foliation intensity in both the gabbro and granite in this location increases with proximity to the shear zone (*see* Photos 2C and 2D). Where deformation is most intense the gabbro becomes mylonitized and locally interlayered with strongly grain-size-reduced potassium feldspar megacrystic granite (*see* Photo 2E). The second location is observed 13 km east-southeast of Geikie Lake and consists of strongly foliated to gneissic, metavolcanic to metasedimentary rocks (Figure 7, *see* Photo 1D). The last observed outcropping and possible continuation of this shear zone consists of strongly foliated mafic metavolcanic rocks and is represented by a single outcrop near the northern tip of Black Sturgeon Lake (Figure 8).

A set of subparallel north-trending faults, which include the Black Sturgeon fault, have been suggested to represent the failed arm of the Keweenawan Midcontinent Rift (Sutcliffe 1991). Near Black Sturgeon Lake, and further north toward Chief Bay, a prominent set of northwest-trending faults is also present. Coates (1972) suggested that these northwest-trending faults in the Black Sturgeon Lake area are *en échelon* and that they controlled the collapse of a large segment of the underlying basement rocks, thereby preserving the Sibley Group sedimentary rocks west of the Black Sturgeon fault. Furthermore, Coates (1972) suggested that displacement of these "blocks" was hinge-like, with little movement in the northwest and greater offset to the southeast. The intersection of these north-trending and northwest-trending faults may form several northwest-elongated blocks (*see* Figure 2) with greatest subsidence or offset at the southeast intersection point. Vertical offset along the northwest-trending faults is

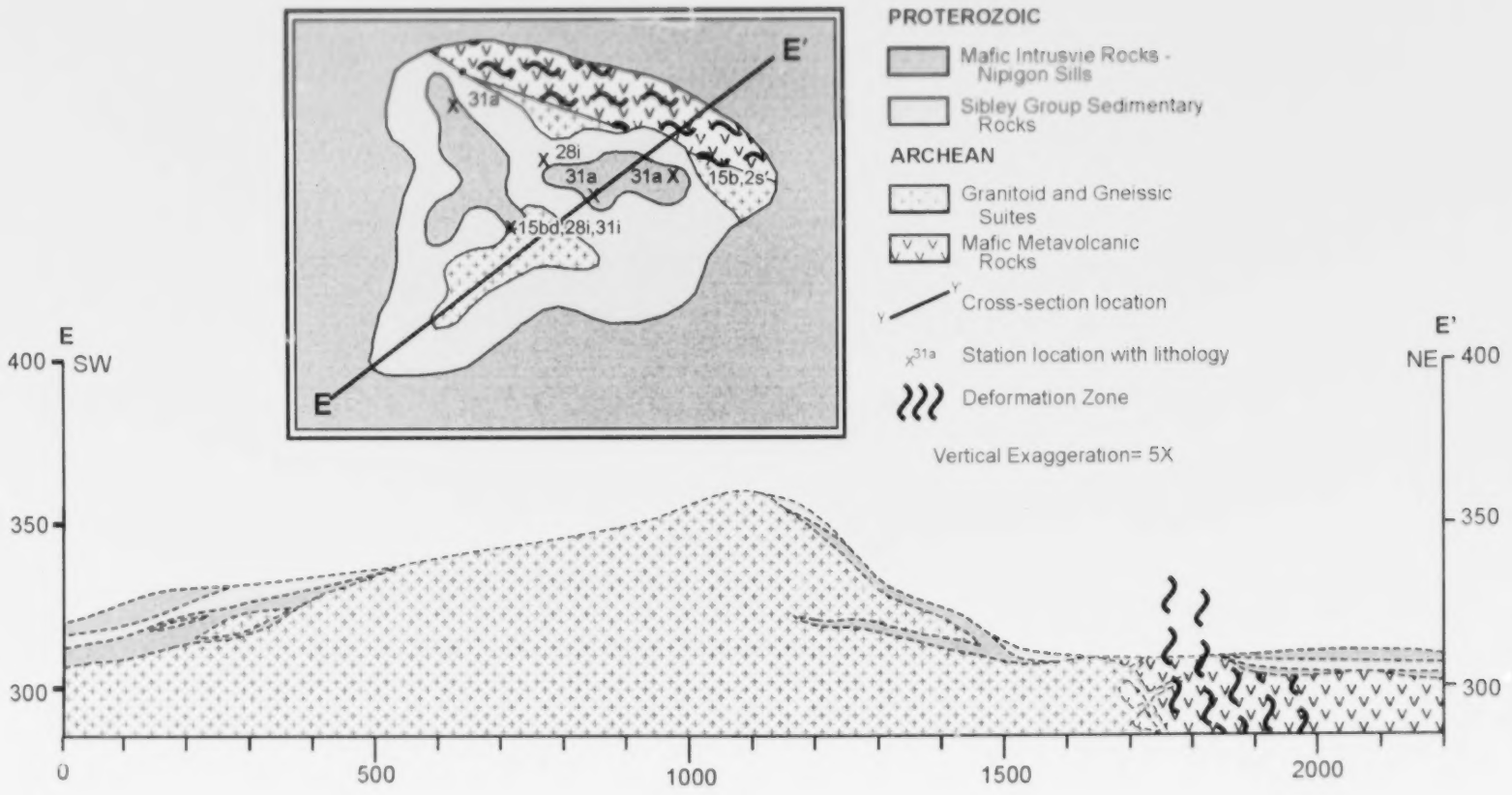
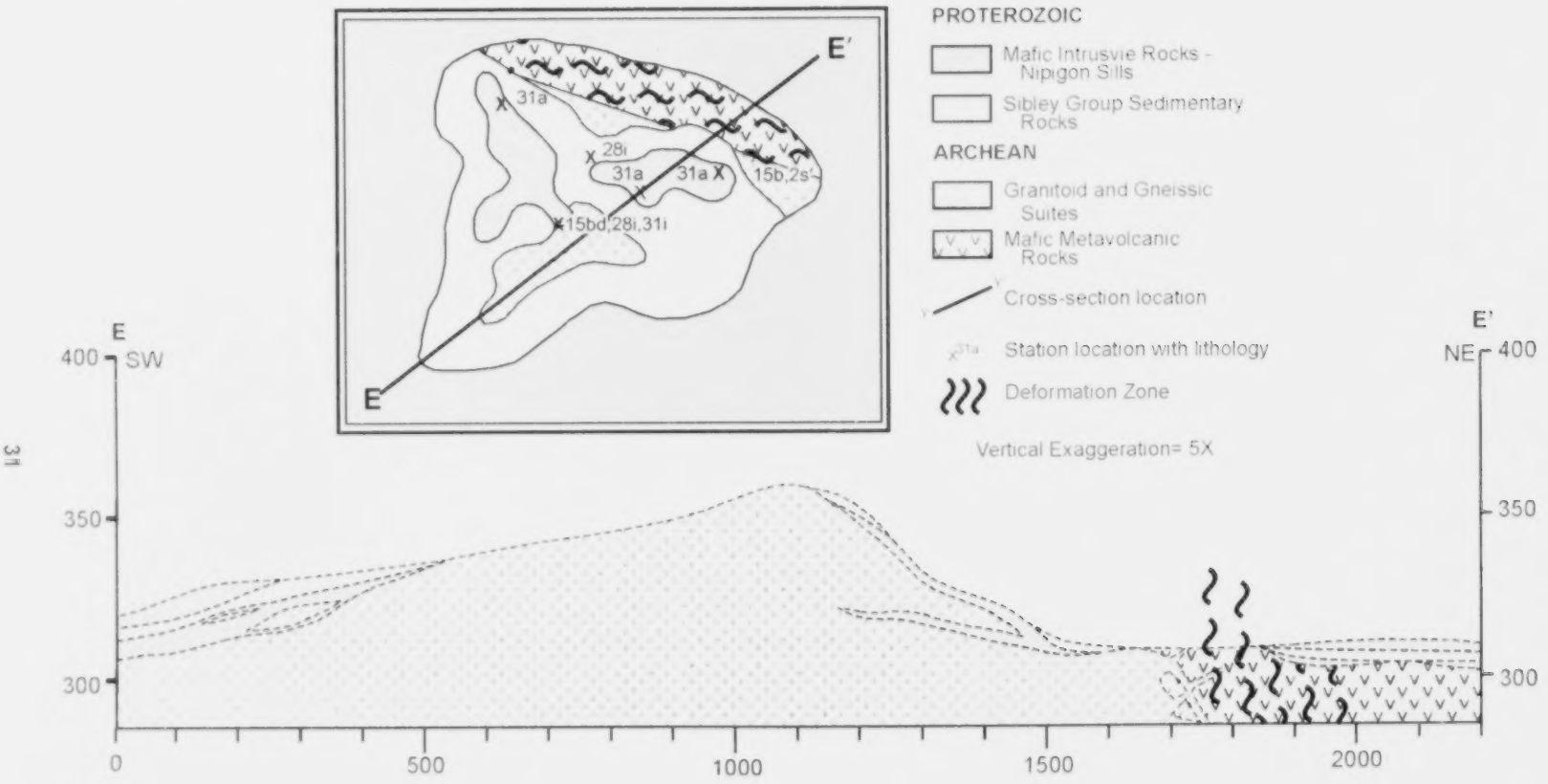


Figure 7. Cross section E–E', located roughly 13 km southeast of Geikie Lake (*see* Figure 2), illustrates the relationship between the Archean basement rocks and the Nipigon diabase sills. Note more than a single sill may be present. In this area, relief on the Archean paleosurface may have influenced sill emplacement and geometry. (Elevation and distance are in metres; see legend on Maps P.3559, P.3560 and P3561, back pocket, for explanation of lithology rock codes used.)



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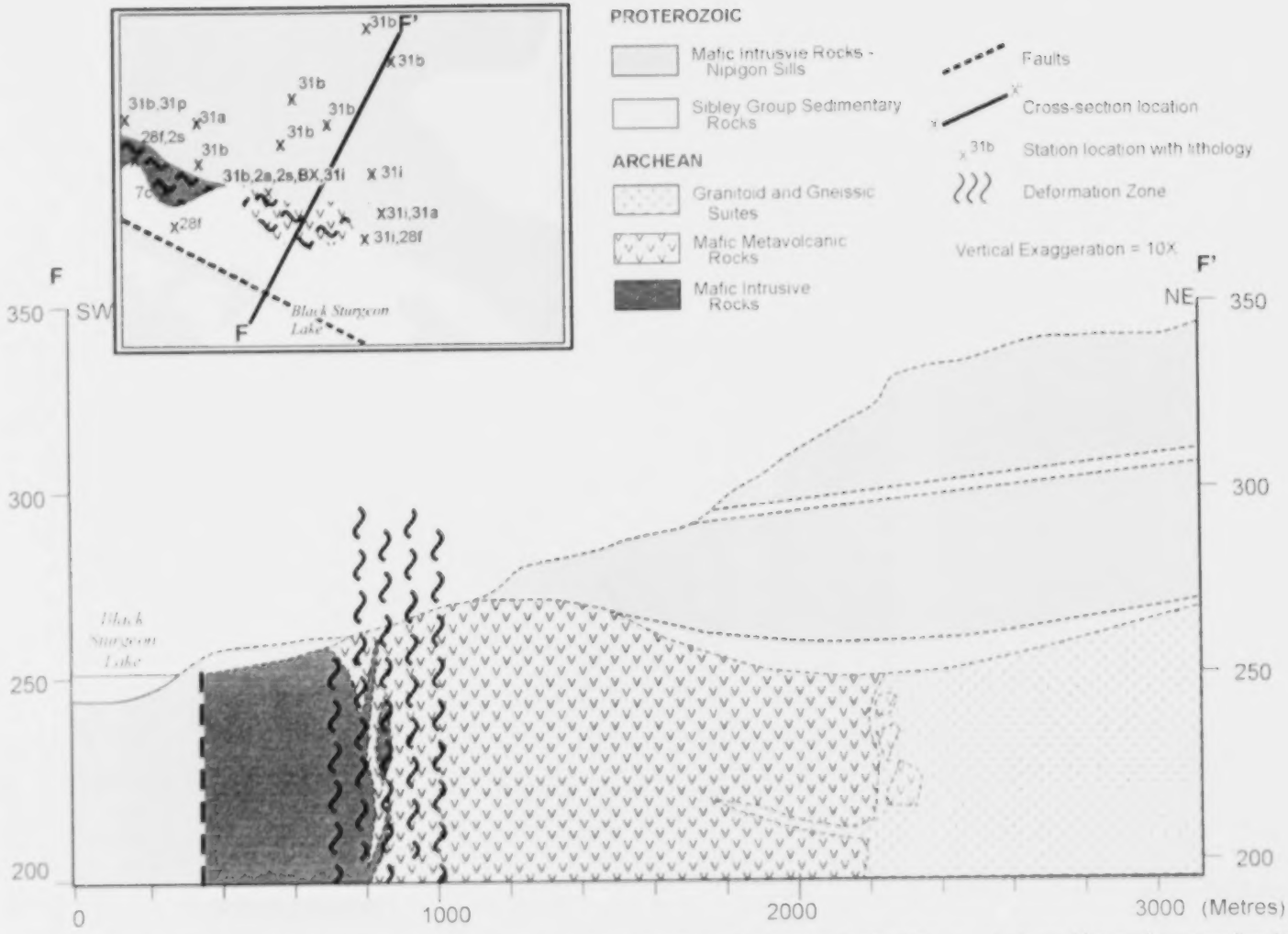


Figure 8. Cross section F–F' northeast of Black Sturgeon Lake (*see* Figure 2), showing the relationship between the Black Sturgeon fault, an older, northwest-trending Archean shear zone, and overlying Sibley Group sedimentary rocks and Nipigon diabase sills. (Elevation and distance are in metres; see legend on Maps P 3559, P 3560 and P3561, back pocket, for explanation of lithology rock codes used.)

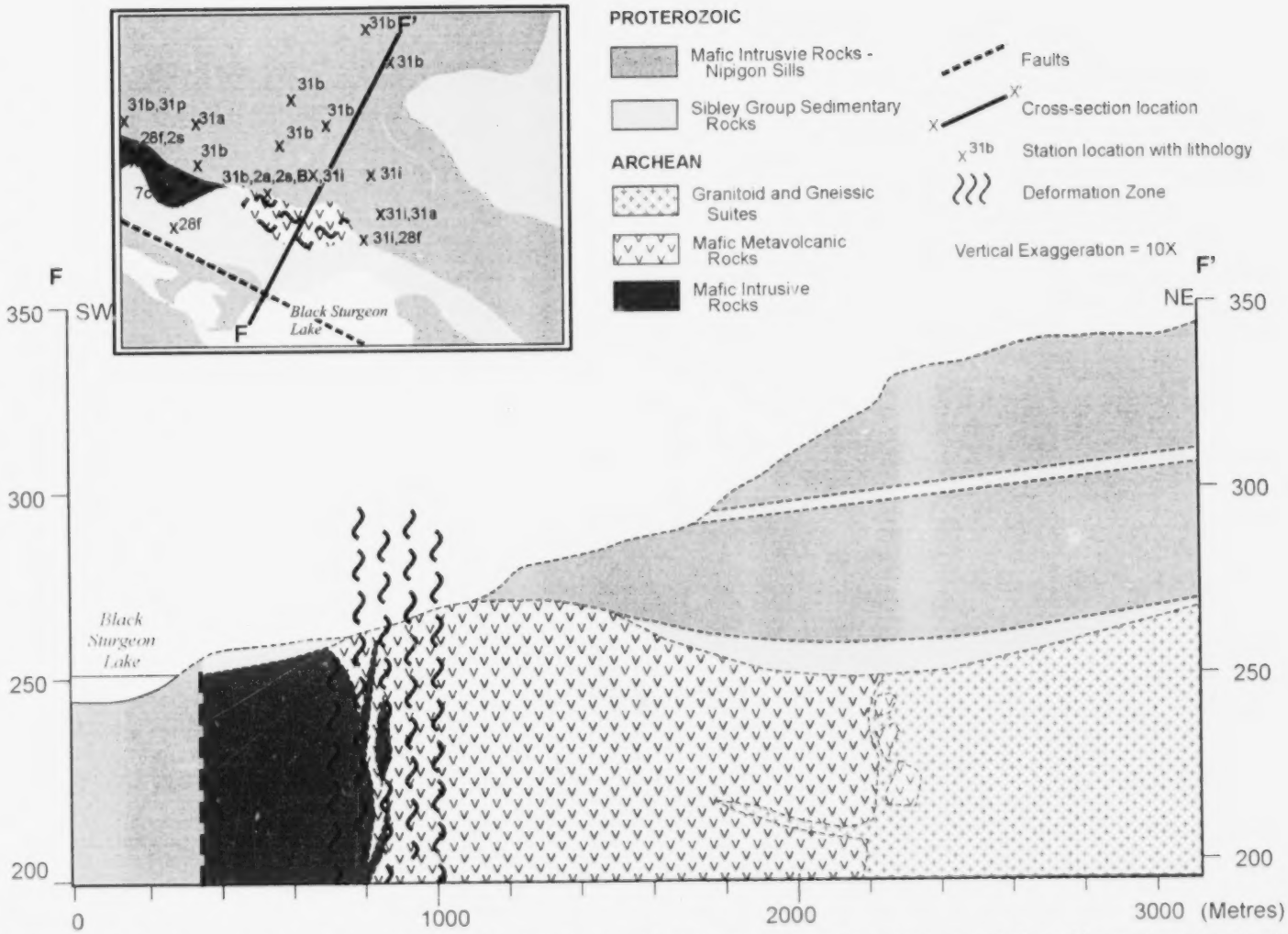


Figure 8. Cross section F–F' northeast of Black Sturgeon Lake (*see* Figure 2), showing the relationship between the Black Sturgeon fault, an older, northwest-trending Archean shear zone, and overlying Sibley Group sedimentary rocks and Nipigon diabase sills. (Elevation and distance are in metres; see legend on Maps P.3559, P.3560 and P3561, back pocket, for explanation of lithology rock codes used.)

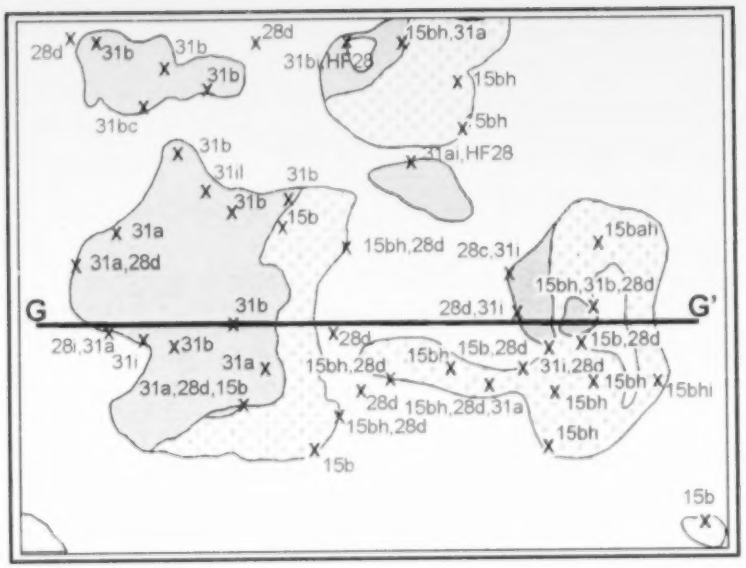
indeterminate; however, significant lateral offset along the northwest- and north-trending structures seems unlikely as Hart and Magyarosi (2004a) observed little lateral displacement across the Black Sturgeon fault, based on correlation of the Archean iron formation on either side of Black Sturgeon Lake.

Schematic cross sections were constructed for several parts of the map area to illustrate the subsurface geology of the map area, as well as some of the offset along the north-trending faults. These cross-sections are shown on Chart A (back pocket), and in Figures 7, 8 and 9.

The cross section A–A′ (*see* Chart A, back pocket) is approximately 30 km long and extends from east of Little Poshkokagan Lake to the east shore of Black Sturgeon Lake. A significant amount of vertical offset along the Black Sturgeon fault must be present; however, the exact amount of offset is indeterminate, as there are no marker horizons and only Archean basement is present on the east side of the Black Sturgeon fault along the trace of the cross section. In the Circle Lake area, if Sibley Group outcrops mapped in the Poshkokagan River valley are part of the same sequence as similar units found in a drill hole near the centre of Black Sturgeon Lake, then there is at least 75 m of vertical offset on the north-trending Circle Lake fault (cross section A–A′, *see* Chart A, back pocket). Offset along another north- to northeast-trending fault is apparent in cross section B–B′ if the elevation of similar Sibley Group rock units in outcrop in the Little Poshkokagan River valley and in drill hole east of Geikie Lake are comparable. This correlation suggests at least 250 m of offset along this fault (cross section B–B', *see* Chart A, back pocket).

Cross sections A–A′ and B–B′ (*see* Chart A, back pocket) suggest the presence of 2 separate diabase sills. Drill hole A-2 (Hudson Bay Exploration and Development Company Limited 1982), located near the centre of Black Sturgeon Lake, west of the Black Sturgeon fault, indicates the presence of diabase beneath a 48 to 55 m thick unit of Sibley Group sedimentary rocks (*see* Chart A, back pocket). Drilling by Platinum Group Metals Limited (2003) on the Pebble property, approximately 13 km east of Poshkokagan Lake, also indicated the presence of a second sill at depth (Platinum Group Metals Limited 2003). Diamond-drill holes PB-02-01 and PB-02-02 (*see* Chart A, back pocket) each indicate 45 to 54 m, respectively, of Sibley Group sedimentary rocks separating an upper and lower diabase sill (*see* Chart A, back pocket) (Platinum Group Metals Limited 2003). A similar thickness of Sibley Group sedimentary rocks, and the possible presence of an upper and lower diabase sill, were also noted in drill holes in the Mikinak Lake (MW02-01) and Grand Bay areas (GB-01-01) (*see* Chart A, back pocket). Drill hole MW02-01, located approximately 0.5 km north of Mikinak Lake, contains an upper and lower diabase sill separated by a thickness of 45 to 50 m of Sibley Group sedimentary rocks that are interspersed with three, 20 cm to 3.5 m, intervals of chilled diabase (Teck Cominco Limited 2003). The upper and lower diabase sills in drill hole GB-01-01 are separated by a thickness of 76.5 m of Sibley Group sedimentary rocks (Canplats Resources Corporation 2001).

The presence of a second diabase sill at depth, or of large lenses or bed-like layers of Sibley Group rocks within individual diabase sills, is also supported by field observations made in 2004 north-northeast of Black Sturgeon Lake and in the Poshkokagan River valley (*see* Figures 8 and 9; cross section B–B', Chart A, back pocket). In these areas, several Nipigon diabase outcrops at different elevations are separated by 1 to 5 m of Sibley Group sedimentary rocks. The presence of disconformable contacts between the Archean granite and overlying Sibley Group sedimentary rocks in the Little Poshkokagan River valley with local areas of basal conglomerate, in addition to areas where the Sibley Group "onlaps" onto topographically higher granite ridges, suggests that the Archean paleotopography may have, in part, controlled Sibley Group sedimentation.



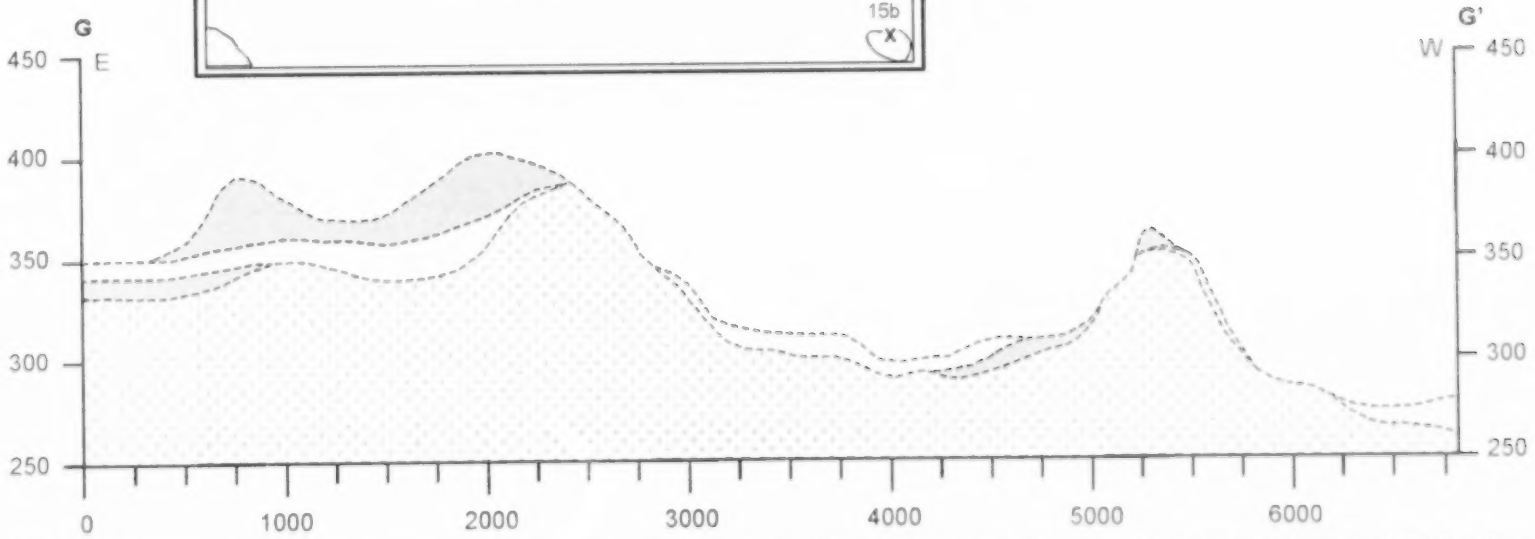
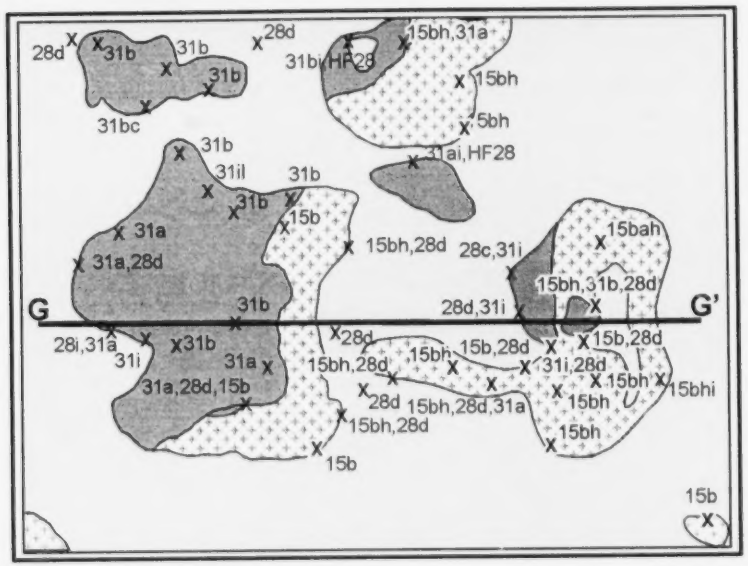


Figure 9. Cross section G–G' in the Poshkokagan River valley (see Figure 2), illustrating the relationship between the Archean granitic basement rocks and the Nipigon diabase sills. In this area, relief on the Archean paleosurface may have influenced sill emplacement and geometry. (Elevation and distance are in metres; see legend on Maps P.3559, P.3560 and P3561, back pocket, for explanation of lithology rock codes used.)



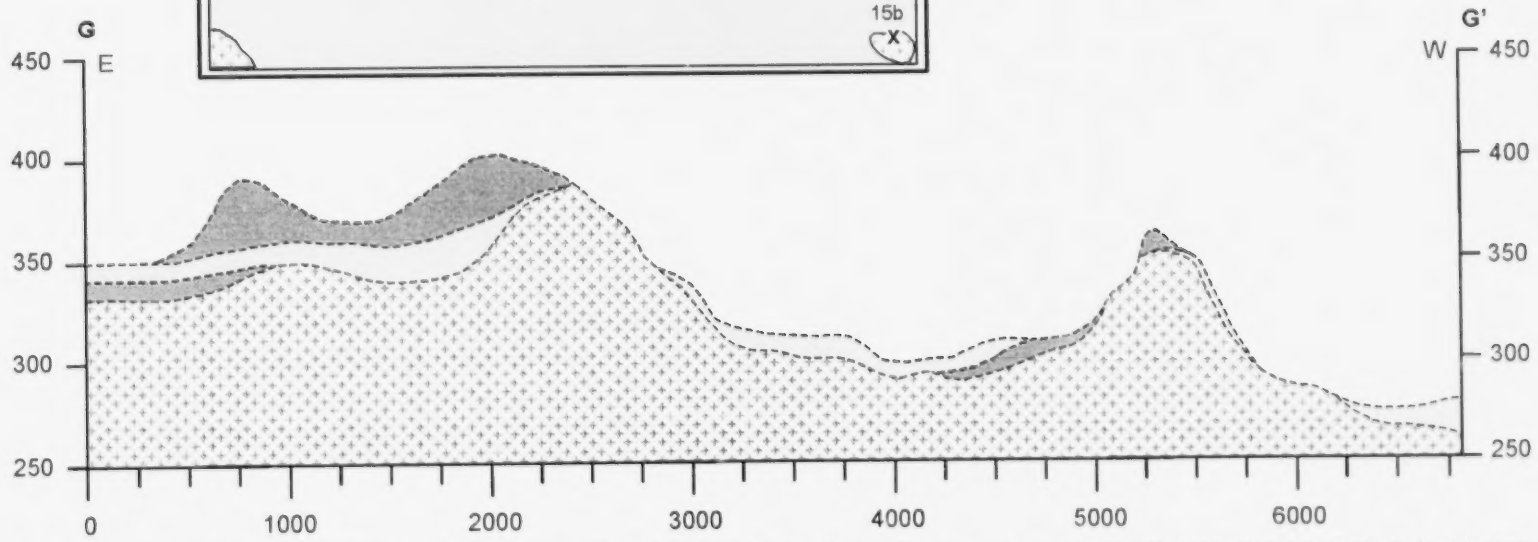


Figure 9. Cross section G–G' in the Poshkokagan River valley (*see* Figure 2), illustrating the relationship between the Archean granitic basement rocks and the Nipigon diabase sills. In this area, relief on the Archean paleosurface may have influenced sill emplacement and geometry. (Elevation and distance are in metres; see legend on Maps P.3559, P.3560 and P3561, back pocket, for explanation of lithology rock codes used.)

Cross section C–C′ (*see* Chart A, back pocket) extends approximately 35 km from 12 km west-southwest of Kabitotikwia Lake to the shore of Lake Nipigon. No drill hole data was used to create this section. The cross section indicates that diabase most likely underlies the mafic metavolcanic inlier north of Geikie Lake.

Geochronology

As part of the LNRGI, over 30 new U/Pb baddeleyite and zircon age determinations will be acquired from the Proterozoic rocks of the Lake Nipigon region, predominantly from mafic intrusive rocks. As of this writing, most of the data was still available only in a preliminary form, and little of it had been published, even in abstracts. Nonetheless, it is possible to provide a summary of some of the main results, as outlined in Heaman et al. (2005).

Detrital zircon ages from a greywacke from the upper Rove Formation of the Animikie Group indicate that it has a maximum depositional age of 1731 Ma, much younger than the underlying upper Gunflint Formation (*circa* 1878 Ma). The youngest grain, at 1731 Ma, is 5% discordant; consequently, a better estimate of maximum depositional age may be provided by a concordant grain at 1777 Ma from the same sample, in addition to the abundance of grains (n=10) in the 1796 to 1777 Ma age range in the sample.

Detrital zircon ages from sandstones of the Pass Lake Formation and Nipigon Bay Formation (lower and upper part of the Sibley Group, respectively) indicate maximum depositional ages of 1634 and 1670 Ma, respectively, with a predominance of Geon 17 and 18, not Archean, detritus. Data from the Outan Island Formation (middle to upper Sibley Group) indicate a maximum depositional age of 1450 Ma, as well as Geon 15 and 17 detritus, but no Geon 18 grains. The Geon 15 detritus may be locally derived, for example, from the English Bay complex volcanic rocks (1547±4 Ma) and the Pillar Lake felsic intrusion (1590±1 Ma). Geon 15 magmatism in the region may have been long-lived (>50 million years), as Davis and Sutcliffe (1985) previously reported a U/Pb zircon age of $1537^{+10}/_{-2}$ Ma from a massive, coarse-grained, possibly intrusive, phase of the English Bay complex.

The flat-lying Pillar mafic volcanic rocks south of Armstrong are younger then 1514 Ma, based on detrital zircons in interbedded sediments, but older than adjacent Nipigon and Inspiration diabase sills.

Baddeleyite data from the 4 ultramafic intrusions in the region being explored for PGE-nickel-copper mineralization shows some scatter within individual intrusions (e.g., from 1107 to 1119 Ma in the Hele intrusion), which could indicate a protracted (up to 10 m.y.) crystallization history for some of these bodies (Heaman et al. 2005). In contrast, baddeleyite age data from 4 different Nipigon diabase sills analyzed so far cluster between 1110 and 1113 Ma. Work on samples from other intrusions in the region, such as the Crystal Lake gabbro and the Logan sills, as well as from geochemical variants of the Nipigon sills, is ongoing.

Geophysical and Rock Property Data

In 2004, the results of a ground gravity survey, carried out along the western and southern margins of Lake Nipigon, were published (Ontario Geological Survey 2004c, 2004d). In addition, 350 specific gravity measurements and 1320 magnetic susceptibility measurements were made during the LNRGI bedrock geology mapping program. Inversion modelling of gravity and aeromagnetic data was carried out on selected areas in the western Nipigon Embayment. This section of the report provides a brief summary of all of these studies.

MAGNETIC SUSCEPTIBILITY

Complementing the 660 *in situ* magnetic susceptibility measurements made in 2003, a further 1320 determinations were made over the course of the 2004 field season. The readings were taken using KT-9 magnetic susceptibility instruments, which have a sensitivity of $1x10^{-5}$ SI units. A minimum of 10 magnetic susceptibility measurements was collected on each outcrop visited. Where an outcrop contained more than one rock type, a set of magnetic susceptibility measurements was collected for each lithology. An average and a standard deviation were calculated for each set of 10 readings. The calculated mean is used as the representative value for the set of measurements and the standard deviation is used to assess the variability of the readings.

The results of the 2003 and 2004 magnetic susceptibility data are summarized in Table 4. The 2004 data include the susceptibilities of intermediate volcanic, Quetico metasedimentary and hornblende suite intrusive rocks, which were not present in the previous year's mapping area. Where comparisons are possible, there is generally good correspondence between magnetic susceptibility measurement on the same rock types in both the 2003 and 2004 mapping areas. However, differences in recorded magnetic susceptibility values are noted for mafic volcanic, Sibley Group sedimentary and biotite granite suite intrusive rocks. The difference in values for mafic volcanic rocks is likely due to the fact that measurements from the 2003 mapping area included Proterozoic rocks of the Pillar Lake area which exhibited generally lower magnetic susceptibilities than those found in Archean mafic metavolcanic rocks in the Nipigon area. The higher magnetic susceptibilities for the limited number of Sibley Group sedimentary rock outcrops examined in 2003 is probably due to the fact that most of these outcrops were hornfelsed. Consequently, the lower values for the 2004 Sibley Group magnetic susceptibility measurements are considered to be more representative of fresh Sibley Group rocks. The much higher magnetic susceptibility values ascribed to biotite granite suite intrusive rocks measured in 2004 versus those measured in 2003 may be due to the inclusion of biotite tonalite suite rocks in this category.

The large number of magnetic susceptibility data collected on diabase sill outcrops, along with the recognition of 3 sill types (Nipigon, Inspiration and Jackfish), indicates that the Inspiration sill type has a generally lower magnetic susceptibility than the other sills. Samples from the Inspiration sill type also have a lower specific gravity (see "Specific Gravity").

Table 4. Averaged magnetic susceptibility values of major rock units in the western Nipigon Embayment (*see* MacDonald and Tremblay (2005) for raw data).

Rock name	Map unit	2003 Mean Magnetic Susceptibility $x10^{-3}$ SI	2004 Mean Magnetic Susceptibility $x10^{-3}$ SI
Mafic volcanic	2	9.51 (29)	16.20 (40)
Intermediate volcanic	3	no samples	16.64 (4)
Felsic volcanic	4	0.15 (3)	1.46 (7)
Quetico metasedimentary rock	6	no samples	1.76 (37)
Synvolcanic mafic intrusive rocks	7	no samples	48.49 (6)
Gneissic suite	11	5.77 (37)	5.91 (5)[1]
Biotite tonalite suite	12	8.54 (30)	6.96 (1)
Pillar Lake intrusion	14	31.75 (21)	no samples
Biotite granite suite	15	0.73 (18)	6.42 (76)
Hornblende suite	16	no samples	13.42 (9)
Quartz-feldspar-porphyry (English Bay complex)	27	0.86 (32)	no samples
Sibley Group sedimentary rocks	28	7.69 (9)	0.89 (42)
Nipigon diabase sill complex	31	24.58 (469)	33.92 (817)

Note that the number of samples measured are shown in brackets. [1] The mean was calculated with one very high value removed.

SPECIFIC GRAVITY

A total of 647 specific gravity measurements were obtained from samples collected during the 2003 and 2004 field seasons. The results of 623 of these are summarised in Table 5. Some values have not been included because either too few measurements were made of a particular rock type to be meaningful, or the values were considered to be invalid.

Table 5. Averaged specific gravity values for major rock units in the western Nipigon embayment (*see* MacDonald and Tremblay (2005) for raw data).

Rock name	Map Unit	Mean Specific Gravity (g/cm^3)	Number of Samples
Mafic volcanic	2	2.87	34
Felsic volcanic	4	2.71	15
Synvolcanic mafic intrusive rocks	7	3.08	21
Gneissic suite	11	2.70	15
Biotite tonalite suite	12	2.67	10
Biotite granite suite	15	2.63	27
Hornblende suite	16	2.74	3
Pillar Lake intrusion	14	2.70	13
Quartz-feldspar-porphyry (English Bay complex)	27	2.58	36
Sibley Group sedimentary rocks	28	2.68	32
Nipigon diabase sill complex	31	3.00	417

The inclusion of the specific gravity values from the 2004 season allows characterisation of mean densities for an additional 5 rock types (synvolcanic mafic intrusive, gneissic, biotite tonalite, biotite granite and hornblende suite rocks) over those reported last year (MacDonald 2004). A larger number of samples, for densities previously reported, has also resulted in improved confidence in calculated means. In particular, higher than expected average specific gravity from 4 Sibley Group sedimentary rock samples, collected in the 2003 field season, has been reduced to a more normal level by the inclusion of an additional 28 samples from the 2004 field season.

The distribution of specific gravity for each rock type are shown in Figures 10, 11 and 12. In some cases, the distribution of density appears to follow a normal distribution (e.g., mafic volcanic rocks, *see* Figure 10A). Other rock types show a less well-defined distribution of density (e.g., synvolcanic mafic intrusive and Pillar Lake intrusive rocks, *see* Figure 11B). The erratic distribution of specific gravity values of some rock units is partly due to limited sample numbers and partly the result of density variations between individual rock types within a suite of rocks.

As noted previously, the Inspiration sill type exhibits a significantly lower magnetic susceptibility than the Nipigon and Jackfish sills. This difference is also evident in the specific gravity data. The mean densities and magnetic susceptibilities for the 3 sill units are summarized in Table 6 and shown on a scatter diagram in Figure 13. Although the mean specific gravity and magnetic susceptibility readings for the Jackfish and Nipigon sills are similar, the Inspiration sill is distinguished by magnetic susceptibility values that are half those of the other 2 sill types, with densities about 0.1 g/cm^3 less.

Table 6. Comparison of magnetic susceptibility and specific gravity data for sill types in the Nipigon Embayment.

Sill Type	Mean Magnetic Susceptibility $x10^{-3}$ SI	Mean Specific Gravity (g/cm^3)
Inspiration	17.52	2.91
Jackfish	30.03	3.03
Nipigon	35.35	3.01

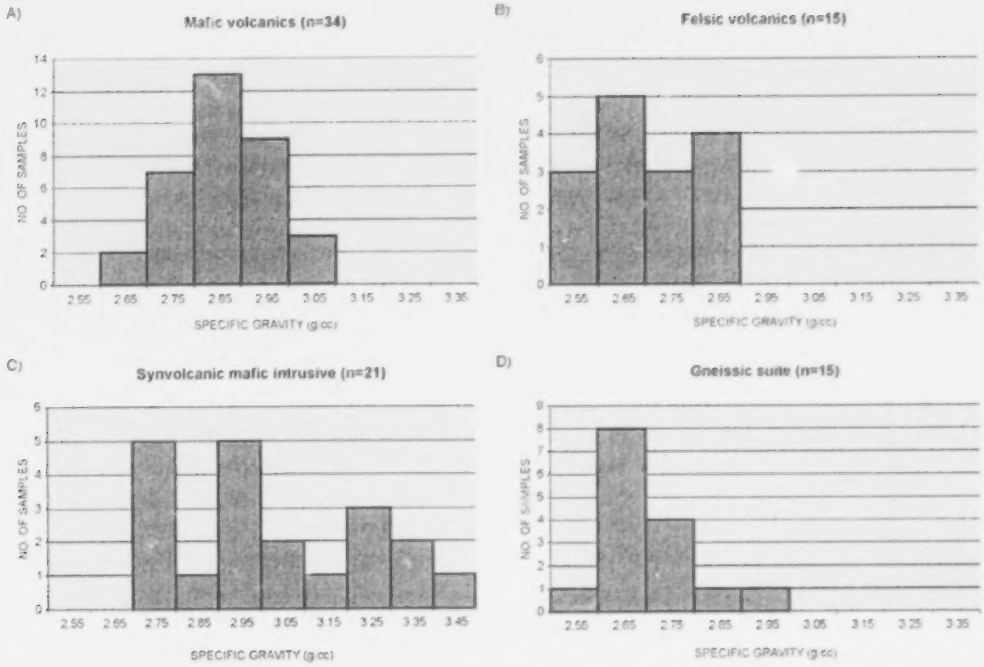


Figure 10. Histograms of specific gravity values for mafic volcanic, felsic volcanic, synvolcanic mafic intrusive and gneissic suite rocks.

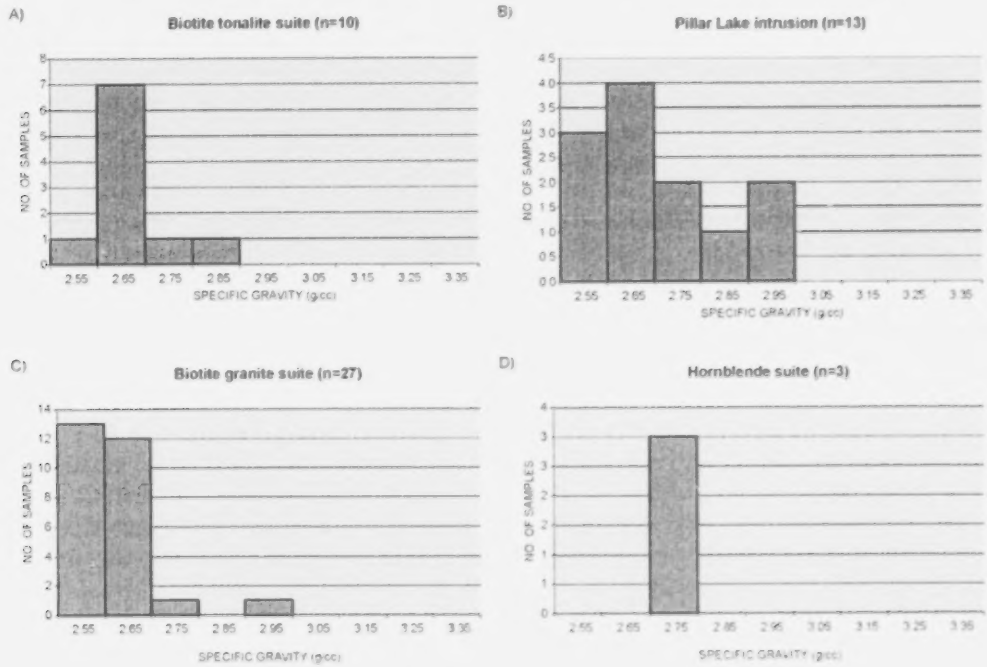


Figure 11. Histograms of specific gravity values for biotite tonalite suite, Pillar Lake intrusion, biotite granite suite and hornblende suite rocks.

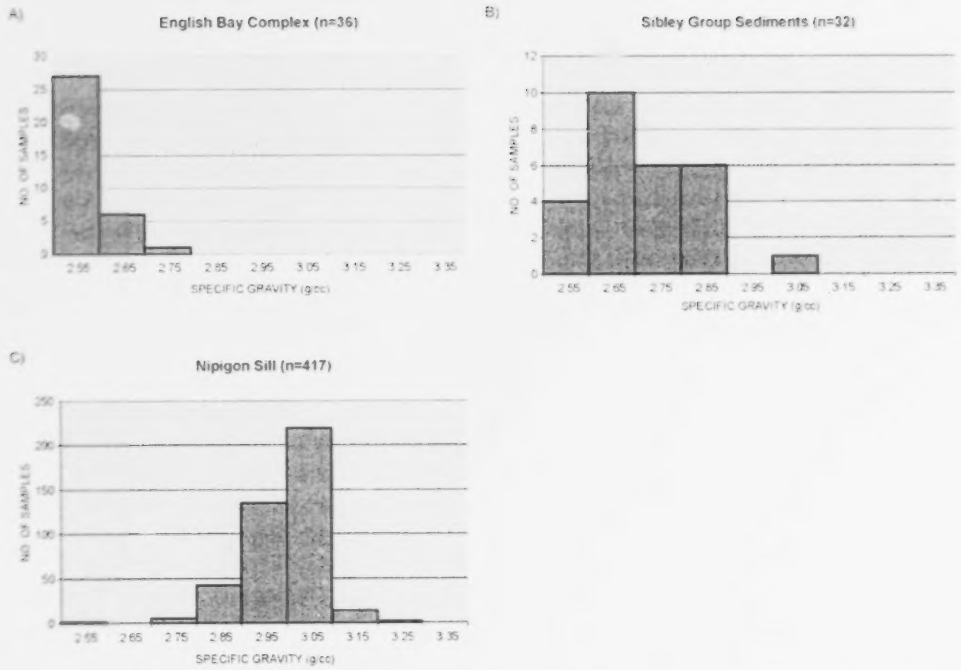


Figure 12. Histograms of specific gravity values for quartz-feldspar prophyry of the English Bay complex, Sibley Group sedimentary and Nipigon sill rocks.

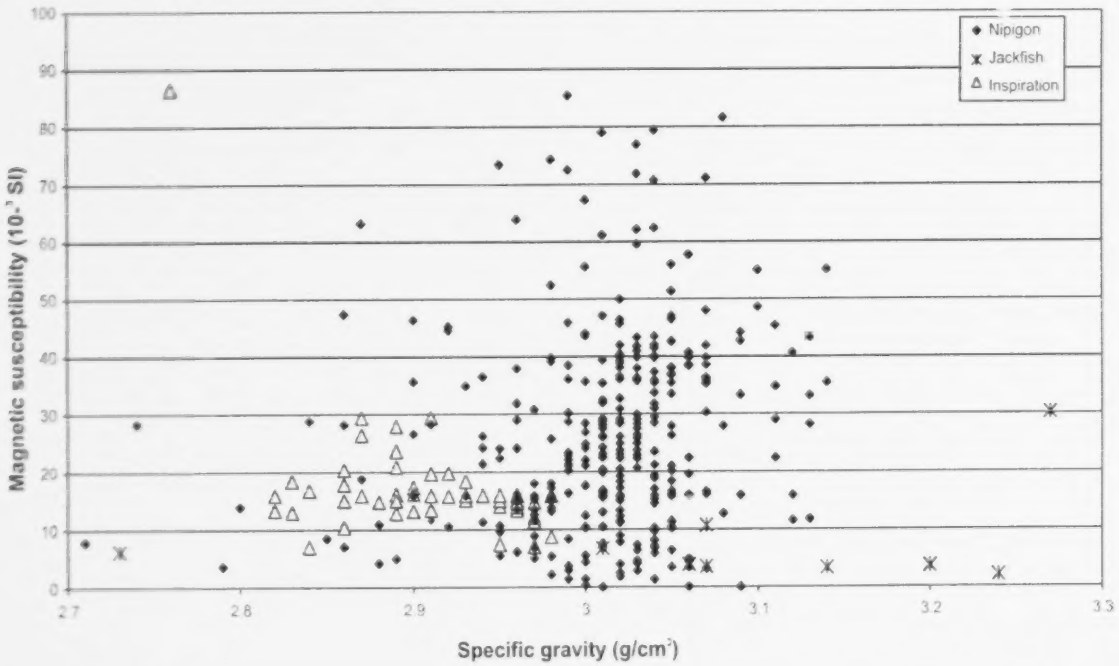


Figure 13. Scatter diagram of magnetic susceptibility versus specific gravity for the Inspiration, Jackfish and Nipigon sills.

GROUND GRAVITY

The results of the ground gravity survey carried out between September 2003 and March 2004 were published in September 2004 in digital form (Ontario Geological Survey 2004c) and as paper maps (Ontario Geological Survey 2004d). The digital publication contains a detailed report describing the survey parameters, logistics and processing. A total of 4091 new data points were acquired and were augmented by 264 values donated by Bitterroot Resources Limited. Station spacing varied from 250m along detailed traverse lines, to about 1 km in the area south of Lake Nipigon, and to about 3 km in the northwestern part of the survey area.

The results from the gravity survey have resulted in a major improvement in the definition of the gravity field of the Nipigon Embayment area over the pre-existing 5 km spaced gravity points in the provincial master gravity database (Ontario Geological Survey 1999). The gross features observed in the data are described with reference to Figure 14, which encompasses both the 2003 and 2004 LNRGI bedrock mapping areas. Starting in the north, a broad arcuate gravity high is observed (G-1). Where the highest Bouguer anomaly amplitude is developed, mafic rocks belonging to the Pillar Lake intrusion have been mapped at surface. The fact that the gravity high is considerably more extensive than the surface expression of the intrusion suggests that similar rocks may be concealed by an overlying Inspiration sill.

Continuing south, a pronounced gravity low (G-2) is observed south of English Bay and east into Lake Nipigon (*see* Figure 14). This gravity feature is at least partially coincident with the low density, quartz-feldspar porphyritic rocks of the English Bay complex. Modelling of the gravity low suggests that the English Bay complex may be more extensive than it appears at surface, extending southwest below Nipigon sills and southeast into Lake Nipigon. It should be noted that the scarcity of gravity data points in the lake resulted in poor definition of the southern and eastern parts of this anomaly and thus, additional uncertainty in the model in this area.

The high Bouguer gravity anomaly (G-3) in the central western part of the area (*see* Figure 14) is associated with outcroppings of Archean greenstone belt rocks. The gravity high is likely caused by the mafic volcanic rocks, which have been shown to have a positive density contrast with the flanking gneissic suite rocks (*see* Table 5). The shape of the gravity high suggests that the mafic volcanic rocks may continue eastward below a Nipigon sill(s).

A high gravity axis (G-4), oriented east to northeast, is defined in the eastern part of the area (*see* Figure 14). Outcrops of synvolcanic mafic intrusive rocks have been mapped along the southern flank of this feature. It is likely that the gravity anomaly is caused by the high density of the mafic intrusive rocks. Modelling of this gravity response suggests that the mafic intrusion may extend for as much as 10 km to the east and west of the outcrop exposures, but is obscured by an overlying Nipigon sill. The west-northwest orientation of this feature is at variance with the northeast regional trend of the Archean supracrustal rocks, which are believed to underlie this area beneath the Nipigon sill. The reason for this variance in trend could either be due to the fact that the model is poorly constrained due to gaps in the gravity coverage, or that the orientation of the modelled intrusion is controlled by a structure that cross cuts the Archean tectonic grain.

Gravity high G-5, which is situated along the western edge of the map area (*see* Figure 14), is similar in shape to, but smaller in size than, the G-3 feature. Like the G-3 anomaly, it is associated with mafic volcanic rocks, which probably account for the elevated gravity values. The limited extent of this anomaly does not suggest that the mafic rocks are much more extensive than as mapped at surface.

A long, linear positive gravity anomaly (G-6), oriented approximately northeast, is located in the southern part of the area (*see* Figure 14). It is more strongly developed at the southwest end and appears to narrow toward the northeast. As the southwest end of the anomaly is directly associated with Archean metavolcanic and metasedimentary rocks in outcrop, the gravity anomaly appears to define the continuation of these units below the Nipigon sill(s) and Sibley Group sedimentary rocks. Modelling suggests that a saddle in the gravity values at about 348000E is due to a major interruption of the volcanic stratigraphy, possibly by a large northwest-trending structure.

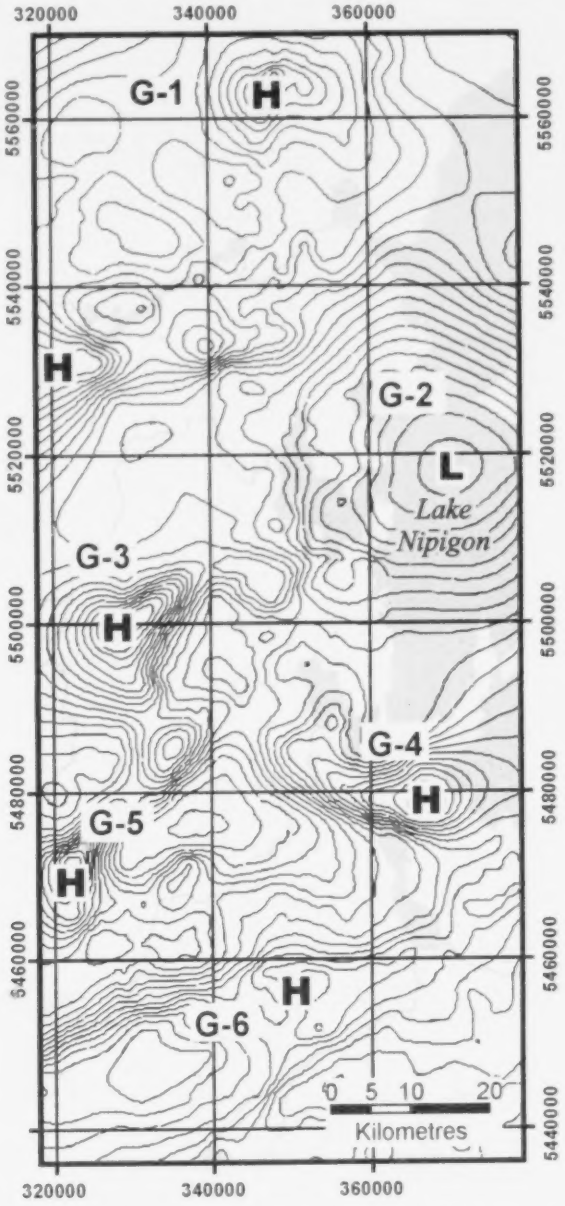


Figure 14. Contoured residual Bouguer gravity along the western margin of Lake Nipigon. Contour interval is 2 milligals. Gravity highs and lows are designated by "Hs" and "Ls", respectively. Features discussed in the text are identified as G-1 to G-6. UTM co-ordinates provide spacial reference.

INVERSION MODELLING

In order to develop a better understanding of certain geophysical signatures and areas of particular geological interest, inversion modelling of the airborne magnetic (Ontario Geological Survey 2004b) and the ground gravity data was performed on selected areas. The gravity and magnetic modelling, which was carried out using University of British Columbia (UBC) inversion software, was run in an unconstrained mode. Unconstrained models are run without a starting model and so are free to fit the data without reference to geological input. The magnetic and gravity models were run independently. The smaller cell size and higher resolution of the magnetic surveys tended to result in the definition of smaller and more complex features than the gravity models, which relied on sparser data and, as a result, yielded larger and smoother features.

Each model was initially viewed using the UBC "meshtools" utility to determine whether a satisfactory result had been obtained. A poor model result could be sometimes improved by adjusting the noise parameters and the removal of a regional gradient. Gravity and magnetic models were combined and displayed as iso-surface "shells" along with surface topography and geology using WinDisp visualization software. Bodies exhibiting magnetic remanence could not be satisfactorily modelled because the modelling algorithm assumes that all responses are caused solely by normal magnetization. As the diabase sills in the area show a considerable amount of remanent magnetic character, this mitigated against developing good models of these bodies. Regardless of the magnetic polarity of the overlying sills, both the gravity and magnetic models were inclined to describe features that lie below the sill, but not the sill itself. This is in spite of the fact that the diabase sills give rise to moderately high magnetic susceptibility and density contrasts. The reason for this is probably due to the small model windows used (which were necessary for reasonable computation times) relative to the large area covered by the sills. As the geophysical footprints of the flat-lying and relatively uniform sills are much larger than the model windows, the parts of the responses contained within the model areas were insufficient for them to be modelled. Contrasting physical properties in the steeply dipping rocks below the sills could be observed in both the magnetic and gravity data, and therefore could be modelled effectively.

The model results from 2 areas, combining the results of 2 gravity models and 3 magnetic models are displayed on Chart B (back pocket). The model 2 block shows a combined magnetic and gravity model centred on an area with a pronounced magnetic anomaly and an associated positive gravity anomaly. The central part of the area is covered by Nipigon sill with a small inlier of mafic volcanic rock. The model suggests that the gravity response is caused by a northeast-striking, steeply dipping body. The body has the same orientation as the exposed Archean metavolcanic rocks to the southeast. The magnetic model indicates that the magnetic response is coming from near the top of the body. Support for this model comes from magnetic susceptibility measurements obtained on drill core from the Geikie Lake GK-01-08 drill hole, which show that a gabbro body intersected below the sill was 5 to 10 times more magnetic than the overlying sill.

Blocks 3 and 4 model 2 strong magnetic anomalies and an east- to northeast-trending gravity high (G-4, previous section). Outcrop exposures indicate that the area is covered mainly by Nipigon sill and Sibley Group sedimentary rocks. The gravity model describes a northwest-oriented high-density body. Outcrop of mafic intrusive rocks along the southern flank of this body is consistent with the model's positive density contrast. A satellite body, to the northeast, is shown by the displayed model shell to be joined to the main body, but it could easily be a separate feature. A magnetic anomaly is associated with this small gravity body. Magnetic modelling indicates a steeply dipping northeast striking body. In the absence of any surface expression of this feature, the attitude of the body, density and magnetic response suggest that it might represent a small Archean mafic intrusion. A larger magnetic anomaly, to the west,

generated a steeply dipping modelled body with a northwest strike. It has the same orientation as, and is partially coincident with, the large northwest trending high-density body discussed above. The orientation of the magnetic and gravity models is nearly perpendicular to the regional strike of the Archean tectonic grain, which suggests that it could be structurally controlled. The magnetic anomaly has been drilled in the Grand Bay area (drill hole GB-01-01) and magnetic susceptibility measurements of the drill core indicate that a gabbro intersected below the Nipigon sill to be significantly more magnetic than the sill itself.

Recommendations for Exploration

Archean metawacke outcrops along the Mawn Lake road locally have been prospected for gold and base metals, particularly in rusty outcrops. If the comparison between the Max–Mawn lakes area and the southern contact of the Beardmore–Geraldton greenstone belt is valid, than the Max Creek deformation zone warrants exploration for gold mineralization, similar to that found along the Paint Lake deformation zone in the Beardmore–Geraldton area. Drilling in one of the Max Lake panels north of Geddes Lake by Canamax Resources Incorporated (1984) intersected 5.45 ppm Au over a 1 m interval in iron formation.

All geochemical samples collected as a part of this study were analyzed for gold, platinum and palladium. Results are published in MRD 146 (MacDonald and Tremblay 2005). No rusty zones or other obvious mineralized areas were identified during the 2004 mapping program.

Platinum group element mineralization in mafic rocks of the Nipigon Embayment is typically hosted within the mafic to ultramafic suite rocks, such as the Seagull and the Disraeli intrusions. Although these types of intrusions are not exposed at surface in the map area, several authors (e.g., Middleton 2001) have suggested that their distribution is related to the north-trending Black Sturgeon fault. If true, then the parts of the map area adjacent to many of the north- and northwest-trending structures in the map area that are interpreted to be extensions or splays of the Black Sturgeon fault may be good areas to explore for subsurface copper-nickel-PGE mineral deposits. In addition, both the Jackfish sill in the 2003 map area, and the Jackfish-like diabase sills in the 2004 map area, are chemically similar to the Kitto mafic to ultramafic intrusion. Consequently, these bodies might have higher copper-nickel-PGE potential than the typical Nipigon diabase sills.

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Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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